# AN EVALUATION OF <u>SCIENCE</u>--<u>A PROCESS APPROACH</u> IN AN EDUCATION IMPROVEMENT PROJECT

A THESIS

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DEDICATION

To My Husband

Wilbur

and

To My Children

James

Claudia

for their patience and encouragement during the period of my graduate study and, especially, during the period of writing this thesis.

L. Y. G.

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The writer wishes to express her sincere thanks to all who have contributed to the successful completion of this research. She wishes specifically to express direct gratitude and appreciation to Dr. David Day, former Director of Curriculum in the Urban Laboratory, and Mr. John Blackshear, Principal of E. A. Ware Elementary School, for their encouragement and service toward the conduct of this study; to Dr. Lynette Saine Gaines and Mrs. Louise Boswell, advisor and co-advisor, respectively, for their constant patience, direction, and guidance throughout the period of this research.

L. Y. G.

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# CHAPTER I

# INTRODUCTION

## Rationale

The development of a curriculum in elementary science called Science--A Process Approach has been carried out over a period of five years by the Commission on Science Education of the American Association for the Advancement of Science. The work of the Commission is supported by the National Science Foundation.[1]

The most striking characteristic of the curriculum materials is that they are intended to teach children the processes of science rather than what may be called science content. They are directed toward developing fundamental skills required in scientific activities. The performances in which these skills are applied involve objects and events of the natural world; the children do, therefore, acquire information from various sciences as they proceed. The goal, however, is not an accumulation of knowledge about any particular domain, such as physics, biology, or chemistry, but

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[1] Commission on Science Education, Science--A Process Approach (Washington, D.C.: American Association for the Advancement of Science, 1964), pts. 1-6.

competence in the use of processes that are basic to all science.

These materials comprise seven parts. The exercises of Part One are intended for kindergarten children, the others for children of successive grades through the sixth.

The exercises of Parts One through Four concern the processes called Observing, Classifying, Communicating, Using Numbers, Measuring, Using Space/Time Relationships, Predicting, and Inferring.[1] A variety of content is used to support the learning of these skills. The exercises in each process grow increasingly complex, making use of what the child has learned before.

In Parts Five, Six, and Seven the exercises deal with the most highly integrated processes called Formulating Hypotheses, Defining Operationally, Controlling Variables, Formulating Models, Interpreting Data, and Experimenting.[2] These more complex activities clearly build upon the simpler skills and knowledge acquired in Parts One through Four. The exercises have a greater number of specific prerequisites which can readily be identified as having been taught in earlier lessons. Although process rather than content remains the focus of attention, the exercises in Parts Five through Seven cover a range of important topics from

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[1] Ibid.

[2] Ibid.

physical science, earth science, life science, and behavioral science.

There is probably a high degree of agreement among informed people concerning the goals of science education. In contrast, the practical matter of how to achieve these goals is likely to be the subject of disagreement. The existence of differing points of view is made particularly apparent when science education begins with the earliest grades of school. Mature scientists are generally aware of their lack of knowledge of what the kindergarten child is like, what interests him, and what he is capable of doing. If one is to begin science education at the earliest school level, one must have a rationale that connects adult behavior with child behavior.[1] There must be a point of view about human development. This is the subject about which most disagreements arise and concerning which, on the current evidence, alternative views are possible. Two prominent viewpoints toward science education which have been discussed repeatedly are the "content" view, and the "creativity" view.

The "content" view is that the best way to learn science is to start to study physics, or biology, or

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[1]Robert M. Gagne, "Psychological Issues in Science--A Process Approach," The Psychological Bases of Science--A Process Approach (Washington, D.C.: American Association for the Advancement of Science, 1965), p. 2.

chemistry, in the earliest grades--not "how a seesaw works," but the process of metabolism. One can't teach these scientific ideas very rapidly in the early grades, but one can painstakingly build up an understanding of them, beginning with very simple notions. This view has some merit, and probably no one would want to say that it is wholly infeasible. It correctly suggests the deficiency in much elementary science teaching as the imparting of isolated facts which perhaps never are connected with a structured body of knowledge. And it is correct in its premise that the children are not too young to learn about science systematically, just so long as what is presented is understandable to them in terms of their previous knowledge. This view seems likely to run into the difficulty that the background knowledge required by the child would require a great deal of time and effort to provide. One can't get very far with force and energy without teaching the child how to make systematic observations, inferences, and measurements. And if one proposes to do this, the question then arises as to whether one should try to teach observation, inference, and measurement in relation to force and energy alone, or whether one ought to try to teach them with reference to animal digestion, solutions of chemicals, and many other kinds of content. Having arrived at this point in thinking, one is led back to a "process" point of view.[1]

[1] *Ibid*.

A very different point of view is that since scientists are creative individuals, one should undertake deliberately to "train creativity." In its extreme form, the argument is that there exists in every individual a general trait, creativity, which is subject to improvement through training, and which will when so developed express itself in a variety of fields, including science. The kind of training needed to accomplish this is a series of situations in which the individual practices having novel ideas and is rewarded for having them.[1]

The process approach has in it a little of both the "content" and "creativity" approaches. Though it rejects concentration on any particular science, it extends the notion of teaching generalizable ideas and skills. While it rejects the notion of "creative ability" as a highly general trait, it adopts the idea that productive thinking can be encouraged in relation to each of the processes of science--observing, inferring, communicating, and so on. The argument is that if transferable intellectual processes are to be developed in the child for application to continued learning in sciences, these must be separately identified, learned, and otherwise nurtured in a systematic manner. It is not enough to be creative "in general"--one must learn to carry out critical and disciplined thinking in connection

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[1] _Ibid_., p. 3.

with each of the processes of science. One must learn to be thoughtful and inventive in observing a variety of specific phenomena, in manipulating many different objects in space and time, in predicting a number of kinds of events, as well as in producing hypotheses.

The child who has learned science processes in this manner should be capable of studying science in the higher grades in a way which is not now possible. It seems probable that such a student will be able to learn about any given science, presented in accordance with its theoretical structure, in far less time than would otherwise be required. Certainly he should have a better conception of science as a way of thinking and discovering.

## Evolution of the Problem

The writer is presently employed as *Science--A Process Approach* liaison teacher in the Urban Laboratory in Education, an Education Improvement Project (EIP) in Atlanta, Georgia. This project involves three elementary schools and is jointly sponsored by the Atlanta Public School System, Atlanta University, Emory University, and funded by the Ford Foundation.

The Education Improvement Project seeks to improve the education of inner-city children through the improvement of instruction by making changes in the curriculum.

The *Science--A Process Approach* curriculum has been used in the Urban Laboratory for three years. The writer felt that an evaluation of this new approach to learning was requisite.

## Contribution to Education

It is hoped that this study will provide baseline data for continuous assessment of pupil growth in *Science--A Process Approach* within the Urban Laboratory, and implications for extending and improving elementary school curricula for all children.

## Statement of the Problem

The problem of this study was to compare and analyze the achievement of kindergarten and primary grade participants in *Science--A Process Approach* in relation to certain academic and personal factors.

## Purposes of the Study

Based on data obtained from competency measures, the following null hypotheses were tested. In *Science--A Process Approach*

1. Kindergarten boys will not perform at a higher level than kindergarten girls.

2. Children in grade one with previous exposure will not perform at a higher level than children in the program for the first time.

3. Children in grade two with two years of previous exposure will not perform at a comparatively higher level than children with one year of previous exposure or children in the program for the first time.

4. There is no advantage for children in the third grade with the longer experience.

5. For the total groups assessed, the percentage of boys performing at a relatively higher level will not be greater than the percentage of girls.

## Limitations of the Study

Due to the fact that Science--A Process Approach is new on the American education scene, and in its infancy in the Atlanta Public School System, this original study was limited in the following ways.

1. Literature on the subject was not in abundance.

2. All data were derived from competency measures that are a part of the built-in evaluation in Science--A Process Approach.

3. No consideration was given to the competence of the classroom teacher in instructional procedures or in administering the evaluation instrument.

4. No control of incidental learning outside of the classroom was provided in the research design.

## Definition of Terms

The following terms were defined for reasons of clarification.

1. "Basic processes of science" - In Science--A Process Approach there are eight basic processes which appear in Parts One, Two, Three, and Four. These are: Observing, Using Space/Time Relationships, Classifying, Using Numbers, Measuring, Inferring, Communicating, and Predicting.[1]

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[1]Commission on Science Education, Science--A Process Approach: Commentary for Teachers (Washington, D.C.: American Association for the Advancement of Science, 1965), p. 10.

2. "Behaviors" - Observable performances which are necessary as well as sufficient indicators of success.[1]

3. "Behavioral Objectives" - Objectives of instruction that clearly state what the child will be able to do or say after instruction with the materials that he was unable to do or say before instruction. These are the basic units upon which assessment depends.[2]

## Locale of the Study

This study was conducted within the Urban Laboratory in Education, the Atlanta University Center, and the Public Library in the city of Atlanta during the spring and summer of 1968.

## Method of Research

The method of research for this study was the descriptive survey utilizing competency measure data which were statistically treated. The statistical treatment used was the evaluation standard adopted in Science--A Process Approach to define levels of expectation with respect to the acquisition of behavior. The 90/90 level of attainment--90 per cent of the children acquire 90 per cent of the specified behaviors,[3] provides a benchmark against which to

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[1] Ibid.

[2] Ibid.

[3] Commission on Science Education, Science--A Process Approach An Evaluation Model and Its Application (Washington, D.C.: American Association for the Advancement of Science, 1968), p. 27.

compare the success of exercises.

The data were statistically treated with reference to the mean, standard deviation, standard error of the mean, standard error of difference between the mean, and "t" ratio.

The null hypotheses were rejected at the .05 level of significance.

## Description of Instrument

The instrument used in this study for assessing the outcomes of instruction is the "Competency Measure," that has been developed for the immediate assessment of what a child is able to do upon completion of an exercise in *Science*--*A Process Approach*. The competency measure consists of tasks intended to assess the achievement of the objectives for each exercise. The effectiveness of the measure is directly related to the accuracy with which the behavioral objectives of each exercise are translated into performance tasks that sample the behaviors described as objectives for that exercise. The validity of the competency measures rests upon the demonstration of the existence of a one-to-one correspondence between the behavioral objectives of the specific process exercise and the tasks required by the competency measure for that exercise. The competency measures are administered individually.[1]

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[1] *Ibid*., pp. 12-13.

## Description of Subjects

The sample of children used to obtain data consisted of three children randomly selected from each class for each competency measure that was administered upon completion of an exercise by the classroom teacher. Competency measure data were available for eight kindergarten classes, eight first grades, eight second grades, and eight third grade classes.

Some children in the sample had exposure to the materials during the 1965-66 school year. These are identified as third-year children. Other children were exposed to them for the first time in 1966-67. These are identified as second-year children. Those identified as first-year children were exposed to the materials for the first time in 1967-68.

## Research Procedure

The following procedural steps were taken in carrying out this study:

1. Related literature was surveyed and summarized.

2. Competency measure data for kindergarten and grades one through three were collected, organized, and classified.

3. The compiled data were compared, analyzed and treated statistically as warranted by the purposes in the study.

4. Conclusions, implications and recommendations based upon the findings are presented in the thesis.

## Survey of Related Literature

The teaching of science has in recent years become a subject of deep concern among educators which has led to many new approaches to the teaching of the subject that require well formulated objectives. These objectives should reflect the basic goal or aim to be achieved. The importance of well formulated objectives are summarized in the statement by Thurber.

> In the final analysis, all objectives for the science program should be determined by the need of the young people. Their needs fall into two categories: (1) those that can be satisfied by acquiring information and special skills and (2) those that can be satisfied by developing certain ways of thinking and acting.[1]

Statements of the objectives of science teaching have been made by many individuals and groups. The most comprehensive and most cited statement was made by the committee which prepared the Forty-Sixth Yearbook of the National Society for the Study of Education in 1947. The NSSE committee used the following criteria in formulating its objectives:

> (1) "...the statement must be practicable for the classroom teacher. It must be usable; when properly used it should lead logically from one step to the next; and if carefully followed, it should result in progress toward the objectives ultimately sought.
>
> (2) "...the statement of objectives should be psychologically sound. It should be based on generally accepted principles of learning and should be as

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[1]Walter A. Thurber, <u>Teaching Science In Today's Secondary Schools</u> (Boston: Allyn and Bacon, Inc., 1959), p. 298.

little subject as possible to conflicting postulates of various theories of the psychology of learning.

(3) "...the objectives should be possible of attainment under reasonably favorable circumstances and to a measurable degree.

(4) "...the selected objectives should be universal in a democratic society. Objectives should not be limited by political or geographical considerations; they should not apply to one sect or creed or racial group any more than to any other.

(5) "...the statement of objectives and the explanatory context should indicate, directly or by clear implications, the relationships of classroom activity to desired changes in human behavior.[1]

Using these five criteria, the committee proposed the following objectives:

A. Functional information or facts about such matters as:
   1. Our universe--earth, sun, moon, stars, weather.
   2. Living things--plants and animals.
   3. The human body--structure, functions, and care.
   4. The nature of matter--elements, compounds, mixtures, chemical changes, solids, liquids, gases.
   5. Energy--sources, types of energy, machines.
   6. Contributions of science to the life of our times--radio, telephones, telegraph, electric lights, motion pictures, household appliances, etc.

B. Functional concepts, such as:
   1. Space is vast.
   2. The earth is very old.
   3. All life has evolved from simpler forms.
   4. All matter is probably electrical in structure.

C. Functional understanding of principles, such as:
   1. All living things reproduce their kind.

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[1]National Society for the Study of Education. Science Education in American Schools, Forty-Sixth Yearbook, Part I (Chicago: University of Chicago Press, 1947).

2. Changes in the seasons and differences in weather and climate depend largely upon relation of the earth to the sun.
3. Energy can be changed from one form to another.
4. All matter is composed of single elements or combinations of elements.
5. Living things in a given environment or locality are mutually interdependent.

D. Instrumental skills, such as ability to:
   1. Read science content with understanding and satisfaction.
   2. Perform fundamental operations with reasonable accuracy.
   3. Perform simple manipulatory activities with science equipment.
   4. Read maps, graphs, charts, and tables and interpret them.
   5. Make accurate measurements, readings, itineraries, etc.

E. Problem-solving skills, such as ability to:
   1. Sense a problem.
   2. Define a problem.
   3. Study the situation for all facts and clues bearing upon the problem.
   4. Make the best tentative explanation or hypothesis.
   5. Select the most likely hypothesis.
   6. Test the hypothesis by experimental or other means.
   7. Accept tentatively, or reject, the hypothesis and test other hypotheses.

F. Attitudes, such as:
   1. Open-mindedness--willingness to consider new facts.
   2. Intellectual honesty--scientific control, withholding conclusions until all available facts are in, not generalizing from insufficient data.

G. Appreciations, such as:
   1. Appreciation of the contribution of scientists.
   2. Appreciation of basic cause-and-effect relationships.
   3. Sensitivity to possible uses and applications of science in personal relationships (attitudes).

H. Interests, such as:
   1. Interest in some phase of science as recreational activity or hobby.
   2. Interest in science as a vocation.[1]

The committee states further that in formulating objectives, it should be practical and usable for the classroom teacher, should be psychologically sound, should be possible to attainment under reasonable favorable circumstances and to a measurable degree, should be universal in a democratic society and the statement of objectives should indicate the relationship of classroom activity to desired change in human behavior. Science teachers must realize that the objectives for the science program should be determined by the need of the particular society in which the objective is being formulated.[2]

The objectives stated by the NSSE committee are by no means the only statements of objectives of science teaching. Such educators as Bernal,[3] Dewey,[4] Weaver,[5] and Brandwein[6] have all made contributions to the objectives of

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[1] Ibid., pp. 78-81.

[2] Ibid., p. 82.

[3] J. D. Bernal, "Science Teaching in General Education," Science and Society, IV (Winter, 1940).

[4] John Dewey, "Method in Science Teaching," Science Education, XXIX, No. 3 (April-May, 1943).

[5] Edward K. Weaver, "A Philosophy for a Sound Science Education Program," Education, LXXX (September, 1950).

[6] Paul F. Brandwein, Fletcher C. Watson, and Paul B. Blackwood, A Book of Methods (New York: Harcourt, Brace and World Co., 1958).

science teaching. According to these authorities and recent studies, the following recommendations may be made:

1. Science education should begin early in the experiences of the child at least by nursery school and kindergarten.

2. Science education at the elementary, secondary, and at least the first two years of college (many propose all of college) levels should be general education (for citizenship, economic efficiency, human relationships, self-realization, and reconstruction of society).

3. For students planning to go to college, the science education should contribute to the student's general education and his preparation for future study rather than emphasize science for participation in college courses.

4. Development of competence in the use of scientific attitudes transcends in importance all other objectives of science education.[1]

On teaching effectiveness and competence in science, Cunningham[2] and Taylor[3] agree that there doesn't seem to be any best method of teaching science. Washton[4] implies that we must try various methods until we find an adequate one for that particular situation.

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[1]Edward K. Weaver, "The Objectives and Philosophy of Science Teaching," Atlanta University School of Education, 1965. (Mimeographed.)

[2]Harry A. Cunningham, "Lecture-Demonstration Versus Individual Laboratory Method in Science Teaching--A Summary," Science Education, XXX (March, 1964), 70-82.

[3]Harold O. Taylor, "A Comparison of Effectiveness of a Lecture Method and a Small Group Discussion Method of Teaching High School Biology," Science Education, XLIV (December, 1959), 442-446.

[4]Nathan S. Washton, Science Teaching in Secondary Schools (New York: Harper Publishing Co., 1961), p. 14.

Havighurst[1] and Charters[2] concur that a knowledge of the students' human growth and development is essential in science teaching. Competencies cannot be described in terms of lists of desirable teacher traits. These traits are meaningless unless they become a part of an individual's pattern of behavior.

In relation to the effectiveness of science teaching, Bryant[3] found that there is a need for a revision of the curricula in the colleges of Atlanta to include:

1. An intensive science program for persons who major in elementary education.

2. Greater emphasis and attention on courses in child growth and development.

3. In-Service programs for learning new methods and materials used in the teaching of science on the elementary level.

Goodlad[4] states that teachers should be trained to construct behavioral objectives in the colleges. His definition of a behavioral objective is one which can be read and interpreted by an observer without the need of

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[1]Robert J. Havighurst, Developmental Tasks and Education (New York: Longmans-Green and Co., 1950), pp. 4-6.

[2]W. W. Charters, Jr., "Human Relation in Education," Review of Educational Research, XXIX (October, 1959), 313-19.

[3]Vera R. Bryant, "Effectiveness of Science Teaching in Certain Atlanta Public Elementary Schools" (unpublished Master's thesis, Atlanta University, 1956), p. 80.

[4]John I. Goodlad, School Curriculum Reform in the United States (New York: The Fund for the Advancement of Education, 1964), pp. 26-27.

supplementary description.[1]

Behavioral descriptions must be designed so as to be specific, clear, and reliable. When these criteria are met, different individuals are able to agree fully on a set of events constituting a representative sampling of each behavior.[2]

Certain questions can serve as guides to be followed in the successful construction of behavioral objectives:

1. Who is to exhibit the behavior?
2. What performance (action) is the learner expected to exhibit?
3. What is the situation which initiates the learner's performance?
4. What object is being acted upon?
5. What constitutes the set of acceptable responses?
6. What special restrictions, if any, are there on the acceptable responses?[3]

Using the above questions as a guide in constructing behavioral objectives will enable the teacher to discover and teach fundamental processes that underlie the fields of science and scientific behavior.

The formation of the Commission on Mathematics of the College Entrance Examination Board in 1955 was probably

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[1] *Ibid.*

[2] *Ibid.*

[3] *Ibid.*

the beginning of curriculum reform which has swept across the nation. With the major impetus provided by the launching of the first Russian sputnik in 1957, many groups and individuals have sought to revise and improve the curriculum of public elementary and secondary schools.

Extensive efforts to reform the curriculum demand careful evaluation, constructive criticism, and the thoughtful concern of educators. A few of the projects have provided step-by-step evaluation procedures, but many have given little thought to continuous appraisal and development.[1]

Almost all persons involved in the curriculum reform movement agree that conventional tests cannot be fairly or accurately used to measure student progress in the new courses.

A basic principle of curriculum development is continuous evaluation. Many of the projects seem to have terminated after brief trial periods in which the courses were tested by teachers and revised. In many cases publishers have taken over, and the original "reformers" have left the scene. Obviously, in such cases, the curricula will be quickly outdated by the explosion of knowledge. Goodlad states that:

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[1]*Ibid*., p. 12.

> New projects should plan to compare patterns organized around single subjects; develop and test materials with children and youth representing divergent cultural groups, especially from disadvantaged environments; and experiment with materials and techniques that challenge and hold the interests of students with widely varying motives, abilities, and part attainments.[1]

Before a supervisor or teacher can determine whether a student has reached certain objectives, he must be able to identify specifically what the student was supposed to achieve. Objectives must be clearly and specifically defined in terms of pupil behavior, and the performance expected of a student if the objective has been achieved must be specified.

There are far too many behavioral characteristics for adequate consideration by teachers in elementary school classrooms, and some of the desired behaviors, while very important, do not lend themselves to evaluation in classroom situations. What the teacher must do is to choose those particular behavior patterns which he feels are important and measurable within the framework of his classroom, and use them as his criteria for evaluation.[2]

Turner[3] concludes that the primary objective of all

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[1] Ibid., p. 84.

[2] U. S. Department of Health, Education and Welfare, Evaluation in Elementary School Science (Washington, D.C.: U. S. Government Printing Office, 1964), p. 22.

[3] Calvin Turner, "The Effectiveness of Science Teaching in Certain Atlanta and Fulton County Public Secondary Schools" (unpublished Master's thesis, School of Education, Atlanta University, 1965).

science education is to provide enough understanding of the place of science in society to enable the great majority that will not be actively engaged in scientific pursuits to collaborate intelligently with those who are and to be able to appreciate or criticize the effects of science on society. Science education must also provide a practical understanding of the processes of science, sufficient to be applicable to the problems which the citizen has to face in his individual and social life.

## Summary of Related Literature

The related literature pertinent to the problem seems to set forth the viewpoints of those investigators who are especially interested in the teaching of science in the elementary school and are summarized in the following paragraphs.

1. Experimentation and innovation have been at the heart of the major curriculum developments for elementary and secondary education during the past decade.

2. New approaches to the teaching of science require the construction of behavioral objectives that are clearly and specifically defined in terms of pupil behavior, and the performance expected of a student if the objective has been achieved.

3. Behavioral objectives will enable the teacher to discover and teach fundamental processes that underlie the fields of science and scientific behavior.

4. School systems should provide and require supplementary work in the methodology and content of the new science programs before for teachers before they attempt to teach the new courses. Also,

colleges should prepare graduates with a good background in both subject matter and methodology for the new science courses.

5. Long-range evaluation programs should be established to determine the effectiveness of the new approaches in meeting the objectives of the science program.

6. Science education in the elementary school should provide children a practical understanding of the processes of science that will enable them to apply a scientific mode of thought to a wide range of problems in life.

## CHAPTER II

## A DESCRIPTION OF SCIENCE--
## A PROCESS APPROACH

The development of an elementary science curriculum called Science--A Process Approach is now approaching completion. This curriculum, for children in kindergarten and grades one through six, has been developed by the Commission on Science Education of the American Association for the Advancement of Science. The five-year effort has been financially supported by the National Science Foundation, and has involved the participation of more than a hundred scientists and educators, representing a wide spectrum of backgrounds, interests, and specialized knowledge.

The following description of _Science_--_A Process Approach_ was taken from the Commentary for Teachers,[1] and an article by Livermore.[2]

### _Characteristics of the Program_

_Science_--_A Process Approach_ shares certain purposes

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[1]_Science_--_A Process Approach, Commentary for Teachers_ (Washington, D. C.: American Association for the Advancement of Science, 1965), pp. 3-58.

[2]A. H. Livermore, "The Process Approach of the AAAS Commission on Science Education Elementary Science Program," _Journal of Research in Science Teaching_, II (1964), 271-82.

and characteristics with other modern science curricula. Like them, it is designed to present instruction which is intellectually stimulating and scientifically authentic. Like other programs, it is based upon the belief that an understanding of the scientific approach to gaining knowledge of man's world has a fundamental importance as a part of the general education of any child.

The program also has characteristics which make it different from other curricula in elementary science. The noteworthy and distinctive features of Science--A Process Approach may be summarized as follows:

1. Instructional materials are contained in booklets written for, and used by, the teacher. Accompanying kits of materials are designed for use by teacher and children. Except for certain work sheets in the later grades, there are no printed materials addressed to the pupil. What the teacher does is to organize and set up science problem situations designed for participation by the children.

2. The topics covered in the exercises sample widely from the various fields of science. The exercises are ordered in sequences of instruction to provide a developmental progression of increasing competence in the processes of science.

3. Each exercise is designed to achieve some clearly stated objectives. These are phrased in terms of the kinds of pupil behavior which can be observed as outcomes of learning upon completion of the exercise.

4. The coverage of fields of science is broad. Mathematics topics are included, to be used when needed as preparation for other science activities. Some of the exercises draw from the social and behavioral sciences. Most involve principles

in physics, biology, and chemistry, with a lesser representation of earth sciences and astronomy.

5. What is to be learned by the children is an accumulative and continually increasing degree of understanding of, and capability in, the processes of science. Progress begins in the kindergarten with observation and description of object properties and motion, and advances through the sixth grade to the design and conduct of scientific experiments on a variety of topics.

6. Methods for evaluating pupils' achievement and progress are an integral part of the instructional program. Each exercise contains a test of pupil achievement reflecting the objectives of the exercise and providing means of assessing its outcomes. In addition, separate measures have been developed for use in determining pupil attainments in process skills prior to instruction.

7. A comprehensive text for the education of teachers is also an integral part of the program. This includes essential general information on the science principles and processes involved in the program, and a set of exercises providing opportunities for teachers to practice relevant instructional techniques.

## The Meaning of Process

There are a number of ways of conceiving of the meaning of "process" as exemplified in Science--A Process Approach. First, it should be mentioned that an emphasis on process implies a corresponding deemphasis on specific science "content." The content is there, but with some exceptions, children are not asked to learn and remember particular facts or principles about objects and phenomena. They are expected to learn such things as how to observe, how to classify, how to infer, how to make and verify hypotheses, and how to perform experiments.

A second meaning of process, referred to by Gagné,[1] centers upon the idea that what is taught to children should resemble what scientists do--the "processes" that they carry out in their own scientific activities. Scientists do observe, and classify, and measure, and infer, and make hypotheses, and perform experiments. How have they come to be able to do these things? Presumably, they have learned to do them, over a period of many years, by practicing doing them. If scientists have learned to gain information in these ways, surely the elementary forms of what they do can begin to be learned in the early grades. This line of reasoning does not imply the purpose of making everyone a scientist. Instead, it puts forward the idea that understanding science depends upon being able to look upon and deal with the world in the ways that the scientist does.

The third and perhaps most widely important meaning of process introduces the consideration of human intellectual development. From this point of view, processes are in a broad sense "ways of processing information." Such processing grows more complex as the individual develops from early childhood onward. The individual capabilities that are developed may reasonably be called "intellectual skills," which many would prefer to the term "processes."

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[1] R. M. Gagné, "Elementary Science: A New Scheme of Instruction," Science, CLI (1966), 49-53.

The instructional program of Science--A Process Approach attempts to deal realistically with the development of intellectual skills, in the sense that the goals to be achieved by any single exercise are modest. In a longer-term sense, substantial and general intellectual development is expected to result from the cumulative effects of an orderly progression of learning activities.

Processes and Intellectual Development

There is a progressive intellectual development within each process category. As this development proceeds, it comes to be increasingly interrelated with corresponding development of other processes. The interrelated nature of the development is explicitly recognized in the kinds of activities undertaken in grades four through six, sometimes referred to as "integrated processes," including controlling variables, defining operationally, formulating hypotheses, interpreting data, and experimenting.

A brief description of the expected sequence of development in basic and integrated process categories is as follows:

Observing. Beginning with identifying objects and object-properties, this sequence proceeds to the identification of changes in various physical systems, the making of controlled observations, and the ordering of a series of observations.

Classifying. Development begins with simple classifications of various physical and biological systems and progresses through multi-stage classifications, their coding and tabulation.

Using numbers. This sequence begins with identifying sets and their members, and progresses through ordering, counting, adding, multiplying, dividing, finding averages, using decimals, and powers of ten. Exercises in number-using are introduced before they are needed to support exercises in the other processes.

Measuring. Beginning with the identification and ordering of lengths, development in this process proceeds with the demonstration of rules for measurement of length, area, volume, weight, temperature, force, speed, and a number of derived measures applicable to specific physical and biological systems.

Using space-time relationships. This sequence begins with the identification of shapes, movement, and direction. It continues with the learning of rules applicable to straight and curved paths, directions at an angle, changes in position, and determinations of linear and angular speeds.

Communicating. Development in this category begins with bar graph descriptions of simple phenomena, and proceeds through describing a variety of physical objects and systems, and the changes in them, to the construction of graphs and diagrams for observed results of experiments.

Predicting. For this process, the developmental sequence progresses from interpolation and extrapolation in graphically presented data to the formulation of methods for testing predictions.

Inferring. Initially, the idea is developed that inferences differ from observations. As development proceeds, inferences are constructed for observations of physical and biological phenomena, and situations are constructed to test inferences drawn from hypotheses.

Defining operationally. Beginning with the distinction between definitions which are operational and those which are not, this developmental sequence proceeds to the point where the child constructs operational definitions in problems that are new to him.

Formulating hypotheses. At the start of this sequence, the child distinguishes hypotheses from inferences, observations, and predictions. Development is continued to the stage of constructing hypotheses and demonstrating tests of hypotheses.

Interpreting data. This sequence begins with descriptions of graphic data and inferences based upon them, and progresses to constructing equations to represent data, relating data to statements of hypotheses, and making generalizations supported by experimental findings.

Controlling variables. The developmental sequence for this integrated process begins with identification of manipulated and responding variables in a description or demonstration of an experiment. Development proceeds to the level at which the student, being given a problem, inference, or hypothesis, actually conducts an experiment, identifying the variables, and describing how variables are controlled.

Experimenting. This is the last of the integrated processes. It is developed through a continuation of the sequence for controlling variables, and includes the interpretation of accounts of scientific experiments, as well as the activities of stating problems, constructing hypotheses, and carrying out experimental procedures.

## Purposes of Science--A Process Approach

From the outset, it has been a guiding purpose to develop a curriculum which could become part of the general education of every child. The goal has not been to produce students of science who have a large amount of highly specialized knowledge. Rather, the aim is for every child to acquire the basic knowledge and point of view which provide him with a highly generalized method of gaining an understanding of himself and the world in which he lives.

Another important purpose has been to provide the student in the elementary grades with some highly generalizable intellectual skills, and some knowledge of scientific procedures for gaining new knowledge, which can serve as a springboard for later study of any of the science. There are some very basic ideas which are important to the understanding of systematic science, and which cannot be readily identified as portions of the traditional elementary curriculum. It is these ideas that are intended to be represented as the "processes" of the new science curriculum.

A related aim is that of providing the child with the kind of knowledge that is generalizable to new situations. This is accomplished, in part, by the use of a variety of content and asking the child to practice making generalizations from one field of science to another.

The program aims for a level of achievement in understanding science and making scientific investigations which has not heretofore been attained by elementary school students. The purpose is to give these children capabilities for thinking and acting in the realm of science which go far beyond what has previously been customary. It is hoped that such capabilities may be applied in all their pursuits, not solely to the further study of scientific subjects.

The materials of the program were prepared with the aim of presenting children with intellectual challenges. Pupils are required to remember few facts, and those few will most probably be retained without effort. However, they are frequently asked to think, to use reasoning, and to invent methods and explanations. This is considered to be an important part of what is meant by learning to use science "processes."

Besides the motivation of curiosity and intellectual challenge, the program intends to make use of achievement motivation. The exercises are aimed at all children, not solely the bright ones. The objectives are intended to be not too difficult for the vast majority of children to achieve. When they are achieved, this accomplishment will reward the child and thus contribute to the maintenance of his interest in further exploration of science and its processes.

## Accomplishments

The goals of *Science--A Process Approach*, although ambitious, appear to be attainable. The instructional materials provide the basic evidence that a systematic course of study in the processes of science has been developed. Successive exercises in each process build upon earlier exercises in a progressive sequence, while at the same time variations in subject matter are deliberately introduced.

Findings have been obtained that show achievement of lower levels of development in each process increases the probability of attaining subsequent steps in intellectual skills.

From the outset the materials of _Science--A Process Approach_ have been subjected to periodic improvement based upon information collected during tryouts in 15 school systems located in various parts of the country. Reports from teachers have provided systematic information on the ease of teaching, technical difficulties, degree of pupil enthusiasm, appraisals of pupil understanding, and related matters. Measures of competence administered to children upon the completion of each exercise have yielded data on the proportion of children achieving each of the defined objectives of the exercise. The target has been to have ninety per cent of the children achieve ninety per cent of the objectives. Evaluative reports on competency measures indicate ninety per cent of the children tested acquired at least seventy per cent of the desired competencies for ninety of 102 exercises in kindergarten, and grades one - three. These data also indicate that ninety per cent of the children reached the eighty per cent level of achievement for all but fourteen of these exercises. When children who had participated in the program for one year were compared with children at the same grade level who had participated for three years, differences favoring the latter group ranged from two to twenty per cent. When achievements of a group of children from a low socio-economic background were compared with those of medium and high levels of family income, it was found that although the former group completed fewer exercises, their success on the completed exercises was as high as that of the other children.

Another notable accomplishment of the program has been its concerted approach to the problem of orienting and educating teachers of elementary science. The need for materials for the education of teachers was recognized early, and much effort has been devoted to the preparation of a course and accompanying materials for the teacher who is preparing to teach the program. Emphasis is given in teacher education to the science processes and their relation to human intellectual development, in addition to helping teachers acquire the competencies included in Science--A Process Approach for application in the classroom.

The distribution of content in Science--A Process Approach in relation to accepted categories of science is approximately as follows: Physical Science, 40 per cent; Life Science, 25 per cent; Mathematics, 18 per cent; Earth Sciences, 10 per cent; Social and Behavioral Sciences, 7 per cent.

## Expectations

What will a "graduate" of Science--A Process Approach be like? What will he know? What will he be able to do? These questions cannot be answered at the present time with any great degree of assurance. The evidence of what these children are like will have to come, after a period of years, from evidence of what they can accomplish in grades subsequent to the sixth. Perhaps it will come from evidence of how they behave toward science in even later periods of their lives.

# CHAPTER III

# PRESENTATION AND INTERPRETATION OF DATA

## Introduction

This chapter presents the data obtained from the competency measures of Science--A Process Approach for the basic processes of Observing, Using Space/Time Relationships, Classifying, Measuring, Using Numbers, Communicating, Inferring, and Predicting. The competency measures were administered during the 1967-68 school year. The data collected were treated statistically, then presented in proper tables analyzed and interpreted.

This chapter is divided into two main divisions each with four major sections. The first major division presents the data on the basis of sex. Its sections are:

Kindergarten
First Grade
Second Grade
Third Grade

The second major division presents the data on the basis of years of exposure to Science--A Process Approach. Its sections are:

Kindergarten
First Grade
Second Grade
Third Grade

Furthermore, these data were analyzed and interpreted at a critical ratio of 1.96 at the five per cent level of confidence and appropriate degrees of freedom for all "t" ratios. The "t" ratios obtained were for the significance of the differences between means.

## Results of Performances of Kindergarten Boys and Girls

The results of the performances of the kindergarten boys and girls on the competency measures of *Science--A Process Approach* are presented in Tables 1 through 6.

### Performances on the competency measures for Process-Observing

The data obtained from the performance of the kindergarten boys and girls on the competency measures for the Process-Observing are presented in Tables 1 and 2 and the paragraphs which follow.

#### Boys

The data on Process-Observing for the thirty-four boys ranged from a low of .00 to a high of 100, with a mean score of 95.97, a standard deviation of 23.20, and a standard error of the mean of 4.04. Twenty-nine or 85 per cent of the boys scored above the mean, five or 15.00 per cent scored below the mean, and none scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores clustered toward the upper end of the distribution, indicating no trend toward normality.

TABLE 1.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Observing) made by ninety-six kindergarten boys and girls in an education improvement project in Atlanta, Georgia, 1967-68

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 29 | 85.00 | 39 | 63.00 | 68 | 71.00 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | .. | .. | 7 | 11.00 | 7 | 7.00 |
| 70 - 79 | 2 | 6.00 | 7 | 11.00 | 9 | 9.00 |
| 60 - 69 | .. | .. | 1 | 2.00 | 1 | 1.00 |
| 50 - 59 | 1 | 3.00 | 5 | 8.00 | 6 | 6.00 |
| 40 - 49 | .. | .. | 1 | 2.00 | 1 | 1.00 |
| 30 - 39 | .. | .. | .. | .. | .. | .. |
| 20 - 29 | 1 | 3.00 | 1 | 2.00 | 2 | 2.00 |
| 10 - 19 | .. | .. | .. | .. | .. | .. |
| 0 - 9 | 1 | 3.00 | 1 | 2.00 | 2 | 2.00 |
| Totals | 34 | 100.00 | 62 | 101.00 | 96 | 99.00 |
| Mean | 95.97 | | 90.30 | | 92.30 | |
| Sigma | 23.20 | | 22.20 | | 22.70 | |
| $Se_m$ | 4.04 | | 2.84 | | 2.31 | |

Girls

In Table 1 it may be noted that in Process-Observing, the sixty-two girls ranged in scores from a low of 0 to a high of 100, with a mean score of 90.30, a standard deviation of 22.20, and a standard error of the mean of 2.84. Thirty-nine or 63.00 per cent of the girls scored above the mean and twenty-three or 38.00 per cent scored below it. None scored in the mean interval. Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. Again as it was in the case of the boys, it was noted that the distribution was skewed in favor of accuracy in observation.

Comparison of boys' and girls' performance on the competency measures of Process-Observing

Table 2 presents the comparative measures for results described in the preceding sections. The difference between

TABLE 2.--Significant differences on the competency measures (Process-Observing) between ninety-six kindergarten boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 95.97 | 23.20 | 4.04 | | | |
| | | | | 5.67 | 4.94 | 1.15 |
| Girls | 90.30 | 22.20 | 2.84 | | | |

the mean performances in Observing was 5.67 in favor of the boys. The standard errors of the two means of 95.97 and 90.30 were 4.04 and 2.84, respectively, and the standard deviation 23.20 and 22.20. In spite of these deviations from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be 4.94 and the "t" ratio, 1.15, with 94 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of kindergarten boys and girls on the competency measures of the Process of Observing was not significant.

Performances on the competency measures for Process-Using Space/Time Relationships

The data obtained from the performance of the kindergarten boys and girls on the competency measures for the Process-Using Space/Time Relationships are presented in Tables 3 and 4 and the paragraphs which follow.

Boys

The data on Process-Using Space/Time Relationships for the twenty-one boys ranged from a low of 80 to a high of 100, with a mean score of 100, a standard deviation of 6.42, and a standard error of the mean of 1.44. None of the boys scored above the mean interval, five or 24.00 per cent scored below the mean, and sixteen or 76.00 per cent scored

TABLE 3.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Using Space/Time Relationships) made by forty-eight kindergarten boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 16 | 76.19 | 16 | 59.30 | 32 | 66.65 |
| 90 - 99 | 3 | 14.28 | 3 | 11.10 | 6 | 12.50 |
| 80 - 89 | 2 | 9.52 | 6 | 22.20 | 8 | 16.65 |
| 70 - 79 | .. | .. | 1 | 3.70 | 1 | 2.90 |
| 60 - 69 | .. | .. | .. | .. | .. | .. |
| 50 - 59 | .. | .. | 1 | 3.70 | 1 | 2.90 |
| Totals | 21 | 99.99 | 27 | 100.00 | 48 | 101.60 |
| Mean | 100 | | 95.97 | | 98.25 | |
| Sigma | 6.42 | | 12.40 | | 10.50 | |
| $Se_m$ | 1.44 | | 2.43 | | 1.53 | |

within the mean interval. When these data were considered in terms of the terms of the representativeness of the sampling distribution, it was noted that the scores clustered toward the upper end of the distribution, indicating no trend toward normality.

Girls

In Table 3 it may be noted that in Process-Using Space/Time Relationships, the twenty-seven girls ranged in scores from a low of 50 to a high of 100, with a mean score of 95.97, a standard deviation of 12.40, and a standard error of the mean of 2.43. Sixteen or 59.00 per cent of the girls scored above the mean and eight or 39.60 per cent scored below it. Three or 11.10 per cent scored in the mean interval. Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. Again as it was in the case of the boys, it was noted that the distribution was skewed in favor of accuracy in Using Space/Time Relationships.

Comparison of boys' and girls' performances on the competency measures of Process-Using Space/Time Relationships

Table 4 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Using Space/Time Relationships was 4.03 in favor of the boys. The standard errors of the two means of 100.00 and 95.97 were 1.44 and 2.43,

TABLE 4.--Significant differences on the competency measures (Processing-Using Space/Time Relationships) between kindergarten boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1 - m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 100.00 | 6.42 | 1.44 | | | |
| | | | | 4.03 | 2.82 | 1.43 |
| Girls | 95.97 | 12.40 | 2.43 | | | |

respectively, and the standard deviation 6.42 and 12.40. In spite of these deviations from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be 2.82 and the "t" ratio, 143, with 46 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of kindergarten boys and girls on the competency measures of the Process of Using Space/Time Relationships was not significant.

### Performances on the competency measures for Process-Classifying

The data obtained from the performance of the kindergarten boys and girls on the competency measures for the Process-Classifying are presented in Tables 5 and 6 and the paragraphs which follow.

boys

The data on Process-Classifying for the five boys ranged from a low of 60 to a high of 100, with a mean score of 88.50, a standard deviation of 15.00, and a standard error of the mean of 7.50. Two or 40.00 per cent of the boys scored above the mean, one or 20.00 per cent scored below the mean, and two or 40.00 per cent scored within the mean interval.

TABLE 5.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Classifying) made by twelve kindergarten boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 2 | 40.00 | 7 | 100.00 | 9 | 75.00 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | 2 | 40.00 | .. | .. | 2 | 16.65 |
| 70 - 79 | .. | .. | .. | .. | .. | .. |
| 60 - 69 | 1 | 20.00 | .. | .. | 1 | 8.35 |
| Totals | 5 | 100.00 | 7 | 100.00 | 12 | 100.00 |
| Mean | 88.50 | | 100.00 | | 97.83 | |
| Sigma | 15.00 | | .. | | 12.50 | |
| $Se_m$ | 7.50 | | .. | | 3.77 | |

Girls

In Table 5 it may be noted that in Process-Classifying all seven girls had perfect scores of 100 on this process. Careful observation of these scores indicated that all were at upper end of the distribution. It was noted that the score received by the girls indicated accuracy in Classifying was mastered by all.

Comparison of boys' and girls' performances on the competency measures of Process-Classifying

Table 6 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Classifying was 11.50 in favor of the girls. The standard errors of the two means of 88.50 and 100.00 were 7.50 and .00, respectively, and the standard deviation 15.00 and .00. In spite of these deviations from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be 7.50 and the "t" ratio, 1.53, with 10 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of kindergarten boys and girls on the competency measures of the Process-Classifying was not significant.

TABLE 6.--Significant differences on the competency measures (Process-Classifying) between twelve kindergarten boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 88.50 | 15.00 | 7.50 | | | |
| | | | | 11.50 | 7.50 | 1.53 |
| Girls | 100.00 | .. | .. | | | |

## Results of Performances of First Grade Boys and Girls

The results of the performances of the first grade boys and girls on the competency measures of Science--A

*Process Approach* are presented in Tables 7 through 14.

## *Performances on the competency measures for Process-Observing*

The data obtained from the performance of the first grade boys and girls on the competency measures for the Process-Observing are presented in Tables 7 and 8 and the paragraphs which follow.

TABLE 7.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Observing) made by fifty-seven first grade boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 15 | 63.50 | 17 | 51.50 | 32 | 56.20 |
| 90 - 99 | .. | .. | 4 | 12.10 | 4 | 7.02 |
| 80 - 89 | 3 | 12.50 | .. | .. | 3 | 5.26 |
| 70 - 79 | 2 | 8.33 | 7 | 21.20 | 9 | 15.80 |
| 60 - 69 | 2 | 8.33 | 3 | 9.10 | 5 | 8.80 |
| 50 - 59 | 2 | 8.33 | 2 | 6.10 | 4 | 7.02 |
| Totals | 24 | 99.99 | 33 | 100.00 | 57 | 100.10 |
| Mean | 92.00 | | 90.26 | | 90.99 | |
| Sigma | 17.60 | | 17.20 | | 17.10 | |
| $Se_m$ | 3.67 | | 3.04 | | 2.29 | |

Boys

The data on Process-Observing for the twenty-four boys ranged from a low of 50 to a high of 100, with a mean score of 92.00, a standard deviation of 17.60, and a standard error of the mean of 3.67. Fifteen or 62.50 per cent of the boys scored above the mean, nine or 37.49 per cent scored below the mean, and none scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores clustered toward the upper end of the distribution, indicating no trend toward normality.

Girls

In Table 7 it may be noted that in Process-Observing the thirty-three girls ranged in scores from a low of 58 to a high of 100, with a mean score of 90.26, a standard deviation of 17.20, and a standard error of the mean of 3.04. Seventeen or 51.50 per cent of the girls scored above the mean and twelve or 36.40 per cent scored below it. Four or 12.10 per cent scored in the mean interval. Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. Again as it was in the case of the boys, it was noted that the distribution was skewed in favor of accuracy in observation.

Comparison of boys' and girls' performances on the competency measures of Process-Observing

Table 8 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Observing was 1.74 in favor of the boys. The standard errors of the two means of 92.00 and 90.26 were 3.67 and 3.04, respectively, and the standard deviation 17.60 and 17.20. In spite of these deviations from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be 4.76 and the "t" ratio, .37, with 55 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of first grade boys and girls on the competency measures of the Process-Observing were not significant.

TABLE 8.--Significant differences on the competency measures (Process-Observing between fifty-seven first grade boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 92.00 | 17.60 | 3.67 | | | |
| | | | | 1.74 | 4.76 | .37 |
| Girls | 90.26 | 17.20 | 3.04 | | | |

Performances on the competency measures for Process-Using Space-Time Relationships

The data obtained from the performance of the first grade boys and girls on the competency measures for the

Process-Using Space/Time Relationships are presented in Tables 9 and 10 and the paragraphs which follow.

TABLE 9.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Using Space/Time Relationships) made by sixty-three first grade boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 14 | 48.60 | 15 | 44.10 | 29 | 46.00 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | 11 | 38.00 | 8 | 23.50 | 19 | 30.20 |
| 70 - 79 | 2 | 6.90 | 6 | 17.65 | 8 | 12.70 |
| 60 - 69 | 1 | 3.50 | 2 | 5.88 | 3 | 4.76 |
| 50 - 59 | 1 | 3.50 | 3 | 8.83 | 4 | 6.35 |
| Totals | 29 | 100.50 | 34 | 99.96 | 63 | 100.01 |
| Mean | 91.75 | | 87.74 | | 89.59 | |
| Sigma | 13.90 | | 16.90 | | 15.70 | |
| $Se_m$ | 2.63 | | 2.95 | | 2.00 | |

Boys

The data on Process-Using Space/Time Relationships for the twenty-nine boys ranged from a low of 56 to a high of 100, with a mean score of 91.75, a standard deviation of 13.90, and a standard error of the mean of 2.63. Fourteen or 48.60 per cent of the boys scored above the mean, fifteen or 51.90 per cent scored below the mean, and none scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores clustered toward the upper end of the distribution, indicating no trend toward normality.

### Girls

In Table 9 it may be noted that in Process-Using Space/Time Relationships the thirty-four girls ranged in scores from a low of 57 to a high of 100, with a mean score of 87.74, a standard deviation of 16.90, and a standard error of the mean of 2.95. Fifteen or 44.10 per cent of the girls scored above the mean and eleven or 32.36 per cent scored below it. Eight or 23.50 per cent scored in the mean interval. Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. As it was in the case of the boys, it was noted that the distribution was skewed in favor of accuracy in Using Space/Time Relationships.

### Comparison of boys' and girls' performances on the competency measures of Process-Using Space/Time Relationships

Table 10 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Using Space/Time

Relationships was 4.01 in favor of the boys. The standard errors of the two means of 91.75 and 87.74 were 2.63 and 2.95, respectively, and the standard deviation 13.90 and 16.90. In spite of these deviations from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be .395 and the "t" ratio, 1.01, with 61 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of first grade boys and girls on the competency measures of the Process of Using Space/Time Relationships was not significant.

TABLE 10.--Significant differences on the competency measures (Process-Using Space/Time Relationships) between first grade boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 91.75 | 13.90 | 2.63 | | | |
| | | | | 4.01 | 3.95 | 1.01 |
| Girls | 87.74 | 16.90 | 2.95 | | | |

## Performances on the competency measures for Process-Measuring

The data obtained from the performance of the first grade boys and girls on the competency measures for the Process-Measuring are presented in Tables 11 and 12 and the paragraphs which follow.

TABLE 11.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Measuring) made by thirty-six first grade boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 10 | 55.50 | 9 | 50.00 | 19 | 52.80 |
| 90 - 99 | 1 | 5.55 | .. | .. | 1 | 2.98 |
| 80 - 89 | .. | .. | 2 | 11.10 | 2 | 5.56 |
| 70 - 79 | 3 | 16.65 | 5 | 27.80 | 8 | 22.20 |
| 60 - 69 | 2 | 11.10 | .. | .. | 2 | 5.56 |
| 50 - 59 | 2 | 11.10 | 2 | 11.10 | 4 | 11.10 |
| Totals | 18 | 99.90 | 18 | 100.00 | 36 | 100.20 |
| Mean | 88.94 | | 88.39 | | 88.67 | |
| Sigma | 19.20 | | 17.70 | | 18.60 | |
| $Se_m$ | 4.67 | | 4.30 | | 3.14 | |

Boys

The data on Process-Measuring for the eighteen boys ranged from a low of 50 to a high of 100, with a mean score of 88.94, a standard deviation of 19.20, and a standard error of the mean of 4.67. Eleven or 61.10 per cent of the boys scored above the mean, seven or 38.85 per cent scored below the mean, and none scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores clustered toward the upper end of the distribution, indicating no trend toward normality.

### Girls

In Table 11 it may be noted that in Process-Measuring the eighteen girls ranged in scores from a low of 60 to a high of 100, with a mean score of 88.39, a standard deviation of 17.70, and a standard error of the mean of 4.30. Nine or 50.00 per cent of the girls scored above the mean and seven or 38.90 per cent scored below it. Two, or 11.10 per cent scored in the mean interval. Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. Again as it was in the case of the boys, it was noted that the distribution was skewed in favor of accuracy in Measuring.

### Comparison of boys' and girls' performances on the competency measures of Process-Measuring

Table 12 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Measuring was .55 in favor of the boys. The standard errors of the two means of 88.94 and 88.39 were 4.67 and 4.30, respectively, and the standard deviation 19.20 and 17.70. In spite of these deviations from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be .636 and the "t" ratio, .09, with 34 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of first grade boys and girls on the competency measures of the Process of Measuring was not significant.

TABLE 12.--Significant differences on the competency measures (Process-Measuring) between first grade boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1 - m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 88.94 | 19.20 | 4.67 | | | |
| | | | | .55 | 6.36 | .09 |
| Girls | 88.39 | 17.70 | 4.30 | | | |

<u>Performances on the competency measures for Process-Using Numbers</u>

The data obtained from the performance of the first grade boys and girls on the competency measures for the Process-Using Numbers are presented in Tables 13 and 14 and the paragraphs which follow.

Boys

The data on Process-Using Numbers for the thirteen boys ranged from a low of 90 to a high of 100, with a mean score of 100, a standard deviation of 2.80, and a standard error of the mean of .81. None of the boys scored above the mean, one or 7.60 per cent scored below the mean, and twelve or 92.40 per cent scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores clustered toward the upper end of the distribution, indicating no trend toward normality.

TABLE 13.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Using Numbers) made by twenty-seven first grade boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 12 | 92.40 | 11 | 78.60 | 23 | 85.20 |
| 90 - 99 | 1 | 7.60 | 2 | 14.30 | 3 | 11.10 |
| 80 - 89 | .. | .. | .. | .. | .. | .. |
| 70 - 79 | .. | .. | .. | .. | .. | .. |
| 60 - 69 | .. | .. | .. | .. | .. | .. |
| 50 - 59 | .. | .. | 1 | 7.15 | 1 | 3.70 |
| Totals | 13 | 100.00 | 14 | 100.05 | 27 | 100.00 |
| Mean | 100.00 | | 99.50 | | 100.00 | |
| Sigma | 2.80 | | 12.00 | | 9.70 | |
| $Se_m$ | .81 | | 3.33 | | 1.90 | |

Girls

In Table 13 it may be noted that in Process-Using

Numbers the fourteen girls ranged in scores from a low of 50 to a high of 100, with a mean score of 99.50, a standard deviation of 12.00, and a standard error of the mean of 3.33. Eleven or 78.60 per cent of the girls scored above the mean and one or 7.15 per cent scored below it. Two or 14.30 per cent scored in the mean interval. Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. Again as it was in the case of the boys, it was noted that the distribution was skewed in favor of accuracy in Using Numbers.

Comparison of boys' and girls' performances on the competency measures of Process-Using Numbers

Table 14 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Using Numbers was .50 in favor of the boys. The standard errors of the two means of

TABLE 14.--Significant differences on the competency measures (Process-Using Numbers) between first grade boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 100 | 2.80 | .81 | | | |
| | | | | .50 | 3.42 | .15 |
| Girls | 99.50 | 12.00 | 3.33 | | | |

100 and 99.50 were .81 and 3.33, respectively, and the standard deviation 2.80 and 12.00. In spite of these deviations from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be 3.42 and the "t" ratio, .15, with 25 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of the first grade boys and girls on the competency measures of the Process of Using Numbers were not significant.

## Results of Performances of Second Grade Boys and Girls

The results of the performances of the second grade boys and girls on the competency measures of *Science--A Process Approach* are presented in Tables 15 through 22.

### Performance on the competency measures for Process-Observing

The data obtained from the performance of the second grade boys and girls on the competency measures for the Process-Using Numbers are presented in Tables 15 and 16 and the paragraphs which follow.

#### Boys

The data on Process-Using Numbers for the eleven boys ranged from a low of 57 to a high of 86, with a mean score of 74.50, a standard deviation of 12.80, and a standard error of the mean of 4.05. Six or 54.50 per cent of the boys scored above the mean, three or 27.20 per cent scored below the mean, and two or 18.20 per cent scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that it did tend to be distributed toward normality.

TABLE 15.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Using Numbers) made by twenty-one second grade boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | .. | .. | 1 | 10.00 | 1 | 4.76 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | 6 | 54.50 | 1 | 10.00 | 7 | 33.40 |
| 70 - 79 | 2 | 18.20 | 5 | 50.00 | 7 | 33.40 |
| 60 - 69 | .. | .. | .. | .. | .. | .. |
| 50 - 59 | 3 | 27.20 | 3 | 3.00 | 6 | 28.50 |
| Totals | 11 | 99.90 | 10 | 100.00 | 21 | 100.60 |
| Mean | 74.50 | | 72.50 | | 73.55 | |
| Sigma | 12.80 | | 14.70 | | 13.80 | |
| $Se_m$ | 4.05 | | 4.90 | | 3.09 | |

Girls

In Table 15 it may be noted that in Process-Using Numbers the ten girls ranged in scores from a low of 57 to a high of 100, with a mean score of 72.50, a standard deviation of 14.70, and a standard error of the mean of 4.90. Two or 20.00 per cent of the girls scored above the mean and three or 30.00 per cent scored below it. Five or 50.00 per cent scored in the mean interval.

Again as it was in the case of the boys, it was noted that the distribution tended toward normality thus, reflecting low accuracy in Using Numbers for this group.

Comparison of boys' and girls' performances on the competency measures of Process-Using Numbers

Table 16 presents the comparative measures for results described in the preceding sections. The difference between the performances in Using Numbers was 2.00 in favor

TABLE 16.--Significant differences on the competency measures (Process-Using Numbers) between twenty-one second grade boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 74.50 | 12.80 | 4.05 | | | |
| | | | | 2.00 | 6.36 | .31 |
| Girls | 72.50 | 14.70 | 4.90 | | | |

of the boys. The standard errors of the two means of 74.50

and 72.50 were 4.05 and 4.90, respectively, and the standard deviation 12.80 and 14.70. The standard error of the difference between means was 6.36 and the "t" ratio, .31, with 19 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade boys and girls on the competency measures of the Process of Using Numbers was not significant.

<u>Performances on the competency measures for Process-Classifying</u>

The data obtained from the performance of the second grade boys and girls on the competency measures for the Process-Classifying are presented in Tables 17 and 18 and the paragraphs which follow.

Boys

The data on Process-Classifying for the seventeen boys ranged from a low of 63 to a high of 100, with a mean score of 93.33, a standard deviation of 12.30, and a standard error of the mean of 3.07. Nine or 53.00 per cent of the boys scored above the mean, eight or 47.00 per cent scored below the mean, and none scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores clustered toward the upper end of the distribution, indicating no trend toward normality.

TABLE 17.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Classifying) made by thirty-nine second grade boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 9 | 53.00 | 12 | 54.50 | 21 | 53.80 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | 5 | 29.40 | 3 | 13.60 | 8 | 20.50 |
| 70 - 79 | 3 | 17.60 | 6 | 27.20 | 9 | 23.10 |
| 60 - 69 | .. | .. | 1 | 4.40 | 1 | 2.50 |
| Totals | 17 | 100.00 | 22 | 99.70 | 39 | 99.90 |
| Mean | 93.33 | | 91.78 | | 92.45 | |
| Sigma | 12.30 | | 14.50 | | 13.60 | |
| $Se_m$ | 3.07 | | 3.17 | | 2.21 | |

Girls

In Table 17 it may be noted that in Process-Classifying the twenty-two girls ranged in scores from a low of 63 to a high of 100, with a mean score of 91.78, a standard deviation of 14.50, and a standard error of the mean of 3.17. Twelve or 54.50 per cent of the girls scored above the mean and ten or 45.20 per cent scored below it. None scored in the mean interval. Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. Again as it was in the case of the boys, it was noted that the distribution was skewed in favor of accuracy in Classifying.

Comparison of boys' and girls' performances on the competency measures of Process-Classifying

Table 18 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Classifying was 1.55 in

TABLE 18.--Significant differences on the competency measures (Process-Classifying) between thirty-nine second grade boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1 - m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 93.33 | 12.30 | 3.07 | | | |
| | | | | 1.55 | 4.42 | .35 |
| Girls | 91.78 | 14.50 | 3.17 | | | |

favor of the boys. The standard errors of the two means of 93.33 and 91.78 were 3.07 and 3.17, respectively, and the standard deviation 12.30 and 14.50. In spite of these deviations from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be 4.42 and the "t" ratio, .35, with 37 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade boys and girls on the competency measures of the Process of

Classifying was not significant.

Performances on the competency measures for Process-Using Space/Time Relationships

The data obtained from the performance of the second grade boys and girls on the competency measures for the Process-Using Space/Time Relationships are presented in Tables 19 and 20 and the paragraphs which follow.

TABLE 19.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Using Space/Time Relationships) made by thirty-six second grade boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 6 | 33.40 | 11 | 61.20 | 17 | 47.30 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | 5 | 27.80 | 1 | 5.55 | 6 | 16.65 |
| 70 - 79 | 1 | 5.55 | 3 | 16.65 | 4 | 11.10 |
| 60 - 69 | 1 | 5.55 | 1 | 5.55 | 2 | 5.55 |
| 50 - 59 | 4 | 22.20 | 1 | 5.55 | 5 | 13.90 |
| 40 - 49 | .. | .. | .. | .. | .. | .. |
| 30 - 39 | .. | .. | .. | .. | .. | .. |
| 20 - 29 | .. | .. | 1 | 5.55 | 1 | 2.80 |
| 10 - 19 | 1 | 5.55 | .. | .. | 1 | 2.80 |
| 0 - 9 | | | | | | |
| Totals | 18 | 100.50 | 18 | 100.05 | 36 | 100.10 |
| Mean | 90.06 | | 88.94 | | 89.94 | |
| Sigma | 24.60 | | 26.10 | | 24.20 | |
| $Se_m$ | 5.97 | | 6.34 | | 4.08 | |

Boys

The data on Process-Using Space/Time Relationships for the eighteen boys ranged from a low of 17 to a high of 100, with a mean score of 90.06, a standard deviation of 24.60, and a standard error of the mean of 5.97. Six or 33.40 per cent of the boys scored above the mean, twelve or 67.10 per cent scored below the mean, and none scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores were scattered approaching normality.

Girls

In Table 19 it may be noted that in Process-Using Space/Time Relationships, the eighteen girls ranged in scores from a low of 29 to a high of 100, with a mean score of 88.94, a standard deviation of 26.10, and a standard error of the mean of 6.34. Eleven or 61.20 per cent of the girls scored above the mean and six or 33.30 per cent scored below it. One or 5.55 per cent scored in the mean interval. Careful observation of these scores indicated them to be scattered rather well along the continuum indicating low accuracy in Using Space/Time Relationships.

Comparison of boys' and girls' performance on the competency measures of Process-Using Space/Time Relationships

Table 20 presents the comparative measures for

TABLE 20.--Significant differences on the competency measures (Process-Using Space/Time Relationships) between thirty-six second grade boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 90.06 | 24.60 | 5.97 | | | |
| | | | | 1.12 | 8.71 | .13 |
| Girls | 88.94 | 26.10 | 6.34 | | | |

results described in the preceding sections. The difference between the mean performances in Using Space/Time Relationships was 1.12 in favor of the boys. The standard errors of the two means of 90.06 and 88.94 were 5.97 and 6.34, respectively, and the standard deviation 24.60 and 26.10. The standard error of the difference between means was 8.71 and the "t" ratio, .13, with 34 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade boys and girls on the competency measures of the Process-Using Space/Time Relationships was not significant.

### Performances on the competency measures for Process-Communicating

The data obtained from the performance of the second grade boys and girls on the competency measures for the Process-Communicating are presented in Tables 21 and 22 and the paragraphs which follow.

TABLE 21.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Communicating) made by twenty-one second grade boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 4 | 44.50 | 6 | 50.00 | 10 | 47.60 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | .. | .. | .. | .. | .. | .. |
| 70 - 79 | 3 | 33.40 | 6 | 50.00 | 9 | 42.90 |
| 60 - 69 | 2 | 22.20 | .. | .. | 2 | 9.50 |
| Totals | 9 | 100.10 | 12 | 100.00 | 21 | 100.00 |
| Mean | 85.61 | | 89.50 | | 87.83 | |
| Sigma | 20.50 | | 15.00 | | 16.10 | |
| $Se_m$ | 7.27 | | 4.52 | | 3.61 | |

Boys

The data on Process-Communicating for the nine boys ranged from a low of 50 to a high of 100, with a mean score of 85.61, a standard deviation of 20.50, and a standard error of the mean of 7.27. Four or 44.50 per cent of boys scored above the mean, five or 55.60 per cent scored below the mean, and none scored within the mean interval.

Girls

In Table 21 it may be noted that in Process-

Communicating the twelve girls ranged in scores from a low of 75 to a high of 100, with a mean score of 89.50, a standard deviation of 15.00, and a standard error of the mean of 4.52. Six or 50.00 per cent of the girls scored above the mean and six or 60.00 per cent scored below it. None scored in the mean interval.

### Comparison of boys' and girls' performances on the competency measures of Process-Communicating

Table 22 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Communicating was 3.89 in favor of the girls. The standard errors of the two means of 85.61 and 89.50 were 7.27, and 4.52, respectively, and the standard deviation 20.50 and 15.00. The standard error of the difference between means was 8.56 and the "t" ratio, .45, with 19 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of

TABLE 22.--Significant differences on the competency measures (Process-Communicating) between twenty-one second grade boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 85.61 | 20.50 | 7.27 | | | |
| | | | | 3.89 | 8.56 | .45 |
| Girls | 89.50 | 15.00 | 4.52 | | | |

confidence the difference in performances of second grade boys and girls on the competency measures of the Process of Communicating was not significant.

## Results of Performances of Third Grade Boys and Girls

The results of the performances of the third grade boys and girls on the competency measures of *Science--A Process Approach* are presented in Tables 23 through 26.

### Performances on the competency measures for Process-Predicting

The data obtained from the performance of the third grade boys and girls on the competency measures for the Process-Predicting are presented in Tables 23 and 24 and the paragraphs which follow.

#### Boys

The data on Process-Predicting for the seventeen boys ranged from a low of 29 to a high of 100, with a mean score of 82.13, a standard deviation of 26.20, and a standard error of the mean of 6.55. Eight or 47.00 per cent of the boys scored above the mean, seven or 41.15 per cent scored below the mean, and two or 11.75 per cent scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores were slightly clustered at the upper end of the distribution.

TABLE 23.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Predicting) made by thirty third grade boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 8 | 47.00 | 7 | 53.80 | 15 | 50.00 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | 2 | 11.75 | 2 | 15.40 | 4 | 13.35 |
| 70 - 79 | 2 | 11.75 | 2 | 15.40 | 4 | 13.35 |
| 60 - 69 | 3 | 17.65 | .. | .. | 3 | 10.00 |
| 50 - 59 | .. | .. | 1 | 7.70 | 1 | 3.34 |
| 40 - 49 | .. | .. | .. | .. | .. | .. |
| 30 - 39 | .. | .. | .. | .. | .. | .. |
| 20 - 29 | 2 | 11.75 | 1 | 7.70 | 3 | 10.00 |
| Totals | 17 | 99.90 | 13 | 100.00 | 30 | 100.04 |
| Mean | 82.13 | | 86.81 | | 85.17 | |
| Sigma | 26.20 | | 23.60 | | 23.10 | |
| $Se_m$ | 6.55 | | 6.48 | | 4.28 | |

Girls

In Table 23 it may be noted that in Process-Predicting the thirteen girls ranged in scores from a low of 29 to a high of 100, with a mean score of 86.81, a standard deviation of 23.60, and a standard error of the mean of 6.48. Seven or 53.80 per cent of the girls scored above the mean and four or 30.80 per cent scored below it. Two or 15.40 per cent scored in the mean interval.

### Comparison of boys' and girls' performances on the competency measures of Process-Predicting

Table 24 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Predicting was 4.68 in favor of the girls. The standard errors of the two means of 82.13 and 86.81 were 6.55 and 6.48, respectively, and the standard deviation 26.20 and 23.60. The standard error of the difference between means was 9.21 and the "t" ratio, .51, with 28 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of third grade boys and girls on the competency measures of the Process of Predicting was not significant.

TABLE 24.--Significant differences on the competency measures (Process-Predicting) between thirty third grade boys and girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1 - m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 82.13 | 26.20 | 6.55 | | | |
| | | | | 4.68 | 9.21 | .51 |
| Girls | 86.81 | 23.60 | 6.48 | | | |

Performances on the competency measures for Process-Inferring

The data obtained from the performance of the third grade boys and girls on the competency measures for the Process-Inferring are presented in Tables 25 and 26 and the paragraphs which follow.

TABLE 25.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Inferring) made by forty-eight third grade boys and girls

| Percentage Scores | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 6 | 24.00 | 3 | 13.10 | 9 | 18.75 |
| 90 - 99 | 6 | 24.00 | 6 | 26.10 | 12 | 25.00 |
| 80 - 89 | 4 | 16.00 | 4 | 17.40 | 8 | 16.65 |
| 70 - 79 | 3 | 12.00 | 3 | 13.10 | 6 | 12.50 |
| 60 - 69 | 1 | 4.00 | 4 | 17.40 | 5 | 10.80 |
| 50 - 59 | 5 | 20.00 | 2 | 8.70 | 7 | 14.60 |
| 40 - 49 | .. | .. | .. | .. | .. | .. |
| 30 - 39 | .. | .. | 1 | 4.35 | 1 | 2.08 |
| Totals | 25 | 100.00 | 23 | 100.15 | 48 | 100.38 |
| Mean | 83.70 | | 80.15 | | 82.00 | |
| Sigma | 18.10 | | 18.10 | | 18.20 | |
| $Se_m$ | 3.70 | | 3.86 | | 2.65 | |

Boys

The data on Process-Inferring for the twenty-five boys ranged from a low of 50 to a high of 100, with a mean score of 83.70, a standard deviation of 18.10, and a standard error of the mean of 3.70. Twelve or 48.00 per cent of the boys scored above the mean, nine or 36.00 per cent scored below the mean, and four or 16.00 per cent scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores scattered throughout the distribution, indicating a normal distribution.

Girls

In Table 25 it may be noted that in Process-Inferring the twenty-three girls ranged in scores from a low of 36 to a high of 100, with a mean score of 80.15, a standard deviation of 18.10, and a standard error of the mean of 3.86. Nine or 39.20 per cent of the girls scored above the mean and ten or 43.55 per cent scored below it. Four or 17.40 per cent scored in the mean interval. Careful observation of these scores indicated them to be normally distributed.

Comparison of boys' and girls' performances on the competency measures of Process-Inferring

Table 26 presents the comparative measures for results described in the preceding sections. The difference

TABLE 26.--Significant differences on the competency measures (Process-Inferring) between forty-eight third grade Boys and Girls

| Group | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| Boys | 83.10 | 18.10 | 3.70 | | | |
| | | | | 3.55 | 5.35 | .66 |
| Girls | 80.15 | 18.10 | 3.86 | | | |

between the mean performances in Inferring was 3.55 in favor of the boys. The standard errors of the two means of 83.10 and 80.15 were 3.70 and 3.86, respectively, and the standard deviation 18.10 and 18.10. The standard error of the difference between means was 5.35 and the "t" ratio, .66, with 46 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of third grade boys and girls on the competency measures of the Process of Inferring was not significant.

## Results of Performances of First Grade Pupils Based on Years of Exposure

The results of the performances of the first grade pupils on the competency measures of Science--A Process Approach based on years of exposure are presented in Tables 27 through 34.

Performances on the competency measures for Process-Observing

The data obtained from the performance of the first grade pupils on the competency measures for the Process-Observing based on years of exposure are presented in Tables 27 and 28 and the paragraphs which follow.

TABLE 27.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Observing) made by fifty-seven first grade pupils

(Years of Exposure)

| Percentage Scores | One Year Exposure | | Two Years Exposure | |
|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent |
| 100 | 6 | 28.60 | 26 | 72.30 |
| 90 - 99 | 3 | 14.30 | 1 | 2.74 |
| 80 - 89 | 2 | 9.50 | 1 | 2.74 |
| 70 - 79 | 4 | 19.00 | 5 | 13.90 |
| 60 - 69 | 2 | 9.50 | 3 | 8.33 |
| 50 - 59 | 4 | 19.00 | .. | .. |
| Totals | 21 | 99.90 | 36 | 100.01 |
| Mean | 82.12 | | 96.44 | |
| Sigma | 18.70 | | 14.30 | |
| $Se_m$ | | | | |

One year exposure

The data on Process-Observing for the first year pupils ranged from a low of 50 to a high of 100, with a mean score of 82.12, a standard deviation of 18.70, and a standard error of the mean of 4.19. Nine or 42.90 per cent of the pupils scored above the mean, ten or 47.50 per cent scored below the mean, and two or 9.50 per cent scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores were normally distributed.

Two years exposure

In Table 27 it may be noted that in Process-Observing the thirty-six second year pupils ranged in scores from a low of 67 to a high of 100, with a mean score of 96.44, a standard deviation of 14.30, and a standard error of the mean of 2.41. Twenty-six or 72.30 per cent of the second year pupils scored above the mean and nine or 24.97 per cent scored below it. One or 2.74 per cent scored in the mean interval Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. It was noted that the distribution was skewed in favor of accuracy in Observing for this group.

Comparison of performances of pupils with one year and two years exposure on the competency measures of Process-Observing

Table 28 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Observing was 14.32 in favor of the second year group. The standard errors of the

TABLE 28.--Significant differences on the competency measures (Process-Observing) between fifty-seven first grade pupils

| (Years of Exposure) | | | | | | |
|---|---|---|---|---|---|---|
| Variables | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
| One Year Exposure | 82.12 | 18.70 | 4.19 | | | |
| | | | | 14.32 | 4.84 | 3.96 |
| Two Years Exposure | 96.44 | 14.30 | 2.41 | | | |

two means of 82.12 and 96.44 were 4.19 and 2.41, respectively, and the standard deviation 18.70 and 14.30. In spite of these deviations from normality of one group the writer followed through on the planned procedures and found a standard error of the difference between means to be 4.84 and the "t" ratio, 3.96, with 55 degrees of freedom. In that this value was greater than 1.96, it was concluded that at the .05 level of confidence the difference in performances of the first grade pupils on the competency measures of the Process of Observing was significant.

Performances on the competency measures for Process-Using Space/Time Relationships

The data obtained from the performance of the first grade pupils on the competency measures for the Process-Using Space/Time Relationships, based on years of exposure are presented in Tables 29 and 30 and the paragraphs which follow.

TABLE 29.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Using Space/Time Relationships) made by sixty-three first grade pupils

(Years of Exposure)

| Percentage Scores | One Year Exposure | | Two Years Exposure | |
|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent |
| 100 | 7 | 25.90 | 22 | 61.20 |
| 90 - 99 | .. | .. | .. | .. |
| 80 - 89 | 10 | 37.00 | 9 | 25.00 |
| 70 - 79 | 4 | 14.80 | 4 | 11.10 |
| 60 - 69 | 3 | 11.10 | .. | .. |
| 50 - 59 | 3 | 11.10 | 1 | 2.78 |
| Totals | 27 | 99.90 | 36 | 100.08 |
| Mean | 85.61 | | 94.75 | |
| Sigma | 15.70 | | 13.20 | |
| $Se_m$ | | | | |

One year exposure

The data on Process-Using Space/Time Relationships for the twenty-seven first year pupils ranged from a low of 56 to a high of 100, with a mean score of 85.61, a standard deviation of 15.70, and a standard error of the mean of 3.08. Seven or 25.90 per cent of the pupils scored above the mean, ten or 37.00 per cent scored below the mean, and ten or 37.00 per cent scored within the mean interval.

Two years exposure

In Table 29 it may be noted that in Process-Using Space/Time Relationships the thirty-six second year first grade pupils ranged in scores from a low of 67 to a high of 100, with a mean score of 94.75, a standard deviation of 13.20, and a standard error of the mean of 2.23. Twenty-two or 61.20 per cent of the second year pupils scored above the mean and fourteen or 38.88 per cent scored below it. None scored in the mean interval. Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. It was noted that the distribution was skewed in favor of accuracy in Using Space/Time Relationships for this group.

Comparison of performances on the competency measures of Process-Using Space/Time Relationships

Table 30 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Using Space/Time Relationships was 9.14 in favor of the second year group. The standard errors of the two means of 85.61 and 94.75 were 3.08 and 2.23, respectively, and the standard deviation 15.70 and 13.20. In spite of the deviations from normality of the second year group, the writer followed through on the planned procedures and found a standard error of the difference between means to be 3.80 and the "t" ratio, 2.41, with 61 degrees of freedom. In that this value was greater than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade pupils on the competency measures of the Process of Using Space/Time Relationships was significant.

TABLE 30.--Significant differences on the competency measures (Process-Using Space/Time Relationships) between sixty-three first grade pupils

(Years of Exposure)

| Variables | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| One Year Exposure | 85.61 | 15.70 | 3.08 | | | |
| | | | | 9.14 | 3.80 | 2.41 |
| Two Years Exposure | 94.75 | 13.20 | 2.23 | | | |

Performances on the competency measures for Process-Using Numbers

The data obtained from the performance of the first grade pupils on the competency measures for the Process-Using Numbers, based on years of exposure are presented in Tables 31 and 32 and the paragraphs which follow.

One year exposure

The data on Process-Using Numbers for the nine first year pupils ranged from a low of 50 to a high of 100, with a mean score of 93.39, a standard deviation of 13.70, and a standard error of the mean of 4.84. Five or 55.50 per cent of the pupils scored above the mean, four or 44.50 per cent scored below the mean and none scored within the mean interval.

TABLE 31.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Using Numbers) made by twenty-seven first grade pupils

(Years of Exposure)

| Percentage Scores | One Year Exposure | | Two Years Exposure | |
|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent |
| 100 | 5 | 55.50 | 18 | 100.00 |
| 90 - 99 | .. | .. | .. | .. |
| 80 - 89 | 3 | 33.40 | .. | .. |
| 70 - 79 | .. | .. | .. | .. |
| 60 - 69 | 1 | 11.10 | .. | .. |
| Totals | 9 | 100.00 | 18 | 100.00 |
| Mean | 93.39 | | 100.00 | |
| Sigma | 13.70 | | .00 | |
| $Se_m$ | 4.84 | | .00 | |

Two years exposure

In Table 31 it may be noted that in Process-Using Numbers all eighteen second year pupils had perfect scores of 100 on this process. Careful observation of these scores indicated that all were clustered at the upper end of the distribution. It was noted that the score received by these pupils with two years of exposure to Science--A Process Approach indicated accuracy in Using Numbers.

Comparison of performances on the competency measures of Process-Using Numbers

Table 32 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Using Numbers was 6.61 in favor of the pupils with two years exposure. The standard

TABLE 32.--Significant differences on the competency measures (Process-Using Numbers) between twenty-seven first grade pupils

(Years of Exposure)

| Variables | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| One Year Exposure | 93.39 | 13.70 | 4.84 | | | |
| | | | | 6.61 | 4.84 | 1.37 |
| Two Years Exposure | 100.00 | .00 | .00 | | | |

errors of the two means of 93.39 and 100.00 were 4.84 and .00, respectively, and the standard deviation 13.70 and .00. In spite of the deviation from normality for second year pupils the writer followed through on the planned procedures and found a standard error of the difference between means to be 4.84 and the "t" ratio, 1.37, with 25 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of first grade pupils on the competency measures of the Process of Using Numbers was not significant.

## Performances on the competency measures for Process-Measuring

The data obtained from the performance of the first grade pupils on the competency measures for the Process-Measuring based on years of experience are presented in Tables 33 and 34 and the paragraphs which follow.

TABLE 33.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Measuring) made by thirty-six first grade pupils

(Years of Exposure)

| Percentage Scores | One Year Exposure | | Two Years Exposure | |
|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent |
| 100 | 1 | 8.35 | 18 | 75.00 |
| 90 - 99 | .. | .. | 1 | 4.17 |
| 80 - 89 | .. | .. | 2 | 8.33 |
| 70 - 79 | 6 | 50.00 | 2 | 8.33 |
| 60 - 69 | 1 | 8.35 | 1 | 4.17 |
| 50 - 59 | 4 | 33.40 | .. | .. |
| Totals | 12 | 100.10 | 24 | 100.00 |
| Mean | 91.17 | | 98.25 | |
| Sigma | 13.20 | | 11.80 | |
| $Se_m$ | 3.98 | | 2.46 | |

One year exposure

The data on Process-Measuring for the twelve pupils being exposed for the first year to Science--A Process Approach ranged from a low of 50 to a high of 100, with a mean score of 91.17, a standard deviation of 13.20, and a standard error of the mean of 3.98. One or 8.35 per cent of the pupils scored above the mean, eleven or 91.75 per cent scored below the mean, and none scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores tended to fall toward the lower end of the distribution indicating a lack of accuracy in Measuring for this group.

Two years exposure

In Table 33 it may be noted that in Process-Measuring the twenty-four second year pupils ranged in scores from a low of 60 to a high of 100, with a mean score of 98.25, a standard deviation of 11.80, and a standard error of the mean of 2.46. Eighteen or 75.00 per cent of the pupils scored above the mean and five or 20.83 per cent scored below it. One or 4.17 per cent scored in the mean interval. Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. It was noted that the distribution was skewed in favor of accuracy in Measuring for pupils exposed two years to Science--

A Process Approach.

Comparison of pupils' performances on the competency measures of Process-Measuring

Table 34 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Measuring was 27.08 in favor of the second year pupils. The standard errors of the means of 71.17 and 98.25 were 3.98 and 2.46, respectively, and the standard deviation 13.20 and 11.80. In spite of the deviation from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be 4.68 and the "t" ratio, 5.79, with 34 degrees of freedom. In that this value was greater than 1.96, it was concluded that at the .05 level of confidence the difference in performances of the first grade pupils on the competency measures of the Process of Measuring was significant.

TABLE 34.--Significant differences on the competency measures (Process-Measuring) between thirty-six first grade pupils

(Years of Exposure

| Variables | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| One Year Exposure | 71.17 | 13.20 | 3.98 | | | |
| | | | | 27.08 | 4.68 | 5.79 |
| Two Years Exposure | 98.25 | 11.80 | 2.46 | | | |

## Results of Performances of Second Grade Pupils Based on Years of Exposure

The results of the performances of the second grade pupils on the competency measures of *Science--A Process Approach* based on years of exposure are presented in Tables 35 through 42.

### Performances on the competency measures for Process-Communicating

The data obtained from the performance of the second grade pupils on the competency measures for the Process-Communicating based on years of exposure are presented in Tables 35 and 36 and the paragraphs which follow.

#### One year exposure

The data on Process-Communicating for the nine pupils with one year exposure ranged from a low of 75 to a high of 100, with a mean score of 84.50, a standard deviation of 14.10, and a standard error of the mean of 4.98. Three or 33.30 per cent of these pupils scored above the mean, six or 66.70 per cent scored below the mean, and none scored within the mean interval.

#### Two years exposure

In Table 35 it may be noted that in Process-Communicating the six pupils with two years exposure ranged in scores from a low of 50 to a high of 100, with a mean of 7.45. One or 16.67 per cent of the pupils scored above the mean and two or 33.33 per cent scored below it. Three or 50.00 per cent scored in the mean interval.

TABLE 35.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Communicating) made by twenty-one second grade pupils

(Years of Exposure)

| Percentage Scores | One Year Exposure | | Two Years Exposure | | Three Years Exposure | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 3 | 33.30 | 1 | 16.67 | 6 | 100.00 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | .. | .. | .. | .. | .. | .. |
| 70 - 79 | 6 | 66.70 | 3 | 50.00 | .. | .. |
| 60 - 69 | .. | .. | .. | .. | .. | .. |
| 50 - 59 | .. | .. | 2 | 33.33 | .. | .. |
| Totals | 9 | 100.00 | 6 | 100.00 | 6 | 100.00 |
| Mean | 84.50 | | 72.83 | | 100.00 | |
| Sigma | 14.10 | | 16.70 | | .00 | |
| $Se_m$ | 4.98 | | 7.45 | | .00 | |

Three years exposure

In Table 35 it may be noted that in Process Communicating the six pupils with three years exposure had perfect scores of 100 on this process. Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. It was noted that the distribution was skewed in favor of accuracy in Communicating.

Comparison of performances of pupils with one year and two years exposure on the competency measures of Process-Communicating

Table 36 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Communicating was 11.67 in favor of the first year pupils. The standard errors of the two means of 84.50 and 72.83 were 4.98 and 7.45, respectively, and the standard deviation 14.10 and 16.70. The standard error of the difference between means was 8.96 and the "t" ratio, 1.38, with 13 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of the second grade pupils on the competency measures of the Process of Communicating was not significant.

Comparison of performances of pupils with one year and three years exposure on the competency measures of Process-Communicating

Table 36 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Communicating was 15.50 in favor of the third year pupils. The standard errors of the two means of 84.50 and 100.00 were 4.98 and .00. In spite of the deviation from normality, the writer followed through

TABLE 36.--Significant differences on the competency measures (Process-Communicating) between twenty-one second grade pupils

(Years of Exposure)

| Variables | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| One Year Exposure | 84.50 | 14.10 | 4.98 | | | |
| | | | | 11.67 | 8.96 | 1.38 |
| Two Years Exposure | 72.83 | 16.70 | 7.45 | | | |
| One Year Exposure | 84.50 | 14.10 | 4.98 | | | |
| | | | | 15.50 | 4.98 | 3.11 |
| Three Years Exposure | 100.00 | .00 | .00 | | | |
| Two Years Exposure | 72.83 | 16.70 | 7.45 | | | |
| | | | | 27.17 | 7.45 | 3.65 |
| Three Years Exposure | 100.00 | .00 | .00 | | | |

on the planned procedures and found a standard error of the difference between means to be 4.98 and the "t" ratio, 3.11, with 13 degrees of freedom. In that this value was greater than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade pupils on the competency measures of the Process of Communicating was significant.

Comparison of performances of pupils with two years and three years exposure on the competency measures of Process-Communicating

Table 36 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Communicating was 27.17 in favor of the third year pupils. The standard errors of the two means of 72.83 and 100.00 were 7.45 and .00, respectively, and the standard deviation 16.70 and .00. In spite of the deviation from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be 7.45 and the "t" ratio, 3.65, with 14 degrees of freedom. In that this value was greater than 1.96, it was concluded that at the .05 level of confidence the difference in performances of the second grade pupils on the competency measures of the Process-Communicating was significant.

Performances on the competency measures for Process-Using Numbers

The data obtained from the performance of the second grade pupils on the competency measures for the Process-Using Numbers, based on years of exposure are presented in Tables 37 and 38 and the paragraphs which follow.

One year exposure

The data on Process-Using Numbers for the nine pupils with one year exposure ranged from a low of 57 to a high of

71, with a mean score of 64.61, a standard deviation of 9.90, and a standard error of the mean of 3.50. Five or 55.60 per cent of the pupils scored above the mean, four or 44.50 per cent scored below the mean, and none scored within the mean interval.

TABLE 37.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Using Numbers) made by twenty-one second grade pupils

(Years of Exposure)

| Percentage Scores | One Year Exposure | | Two Years Exposure | | Three Years Exposure | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | .. | .. | .. | .. | 1 | 16.67 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | .. | .. | 3 | 50.00 | 4 | 66.67 |
| 70 - 79 | 5 | 55.60 | 2 | 33.33 | | |
| 60 - 69 | .. | .. | .. | .. | .. | .. |
| 50 - 59 | 4 | 44.50 | 1 | 16.67 | 1 | 16.67 |
| Totals | 9 | 100.10 | 6 | 100.00 | 6 | 100.01 |
| Mean | 64.61 | | 76.17 | | 86.17 | |
| Sigma | 9.90 | | 11.80 | | 14.60 | |
| $Se_m$ | 3.50 | | 5.28 | | 6.52 | |

Two years exposure

In Table 37 it may be noted that in Process-Using

Numbers the six pupils with two years exposure ranged in scores from a low of 57 to a high of 86, with a mean score of 76.17, a standard deviation of 11.80, and a standard error of the mean of 5.28. Three or 50.00 per cent of the pupils scored above the mean and one or 16.67 per cent scored below it. Two or 33.33 per cent scored in the mean interval.

### Three years exposure

The data on Process-Using Numbers for the six third year pupils ranges from a low of 57 to a high of 100, with a mean score of 86.17, a standard deviation of 14.60, and a standard error of the mean of 6.52. One or 16.67 per cent of the pupils scored above the mean, one or 16.67 per cent scored below the mean, and four or 66.67 per cent scored within the mean interval.

### Comparison of performances of pupils with one year and two years exposure on the competency measures of Process-Using Numbers

Table 38 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Using Numbers was 11.56 in favor of the second year pupils. The standard errors of the means of 64.61 and 76.17 were 3.50 and 5.28, respectively, and the standard deviation 9.90 and 11.80. The standard error of the difference between means was 6.33 and the "t"

TABLE 38.--Significant differences on the competency measures (Process-Using Numbers) between twenty-one second grade pupils

(Years of Exposure)

| Variables | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| One year Exposure | 64.61 | 9.90 | 3.50 | | | |
| | | | | 11.56 | 6.33 | 1.83 |
| Two Years Exposure | 76.17 | 11.80 | 5.28 | | | |
| One Year Exposure | 64.61 | 9.90 | 3.50 | | | |
| | | | | 19.56 | 7.40 | 2.64 |
| Three Years Exposure | 86.17 | 14.60 | 6.52 | | | |
| Two Years Exposure | 76.17 | 11.80 | 5.28 | | | |
| | | | | 10.00 | 8.39 | 1.19 |
| Three Years Exposure | 86.17 | 14.60 | 6.52 | | | |

ratio, 1.83, with 13 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade pupils on the competency measures of the Process of Using Numbers was not significant.

Comparison of performances of pupils with one year and three years exposure on the competency measures of Process-Using Numbers

Table 38 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Using Numbers was 19.56 in favor of third year pupils. The standard errors of the two means of 64.61 and 86.17 were 3.50 and 6.52, respectively, and the standard deviation 9.90 and 14.60. The standard error of the difference between means was 7.40 and the "t" ratio, 2.64, with 13 degrees of freedom. In that this value was greater than 1.96, it was concluded that at the .05 level of confidence the difference in performances of the second grade pupils on the competency measures of the Process of Using Numbers was significant.

Comparison of performances of pupils with two years and three years exposure on the competency measures of Process-Using Numbers

Table 38 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Using Numbers was 10.00 in favor of the third year pupils. The standard errors of the two means of 76.17 and 86.17 were 5.28 and 6.52, respectively, and the standard deviation 11.80 and 14.60. The standard error of the difference between means was 8.39 and the "t" ratio, 1.19, with 10 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade pupils on the competency measures of the Process-Using Numbers was not significant.

Performances on the competency measures for Process-Classifying

The data obtained from the performance of the second grade pupils on the competency measures for the Process-Classifying, based on years of exposure to Science--A Process Approach are presented in Tables 39 and 40 and the paragraphs which follow.

TABLE 39.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Classifying) made by thirty-nine second grade pupils

(Years of Exposure)

| Percentage Scores | One Year Exposure | | Two Years Exposure | | Three Years Exposure | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 8 | 66.67 | 7 | 46.67 | 6 | 50.00 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | 2 | 16.67 | 3 | 20.00 | 3 | 25.00 |
| 70 - 79 | 2 | 16.67 | 4 | 26.67 | 3 | 25.00 |
| 60 - 69 | .. | .. | 1 | 6.67 | .. | .. |
| Totals | 12 | 100.01 | 15 | 100.01 | 12 | 100.00 |
| Mean | 96.15 | | 89.84 | | 92.00 | |
| Sigma | 12.10 | | 14.50 | | 13.00 | |
| $Se_m$ | 3.65 | | 3.88 | | 3.92 | |

One year exposure

The data on Process-Classifying for the twelve first year pupils ranged from a low of 75 to a high of 100, with a mean score of 96.15, a standard deviation of 12.10, and a standard error of the mean of 3.65. Eight or 66.67 per cent of the pupils scored above the mean, four or 33.34 per cent scored below the mean, and none scored within the mean interval.

Two years exposure

In Table 39 it may be noted that in Process-Classifying second year pupils ranged in scores from a low of 63 to a high of 100, with a mean score of 89.84, a standard deviation of 14.50, and a standard error of the mean of 3.88. Seven or 46.67 per cent of the pupils scored above the mean and eight or 53.34 per cent scored below it. None scored in the mean interval.

Three years exposure

The data on Process-Classifying for the twelve third year pupils ranges from a low of 75 to a high of 100, with a mean score of 92.00, a standard deviation of 13.00, and a standard error of the mean of 3.92. Six or 50.00 per cent of the pupils scored above the mean, six or 50.00 per cent scored below the mean, and none scored within the mean interval.

Comparison of performances of pupils with one year and three years exposure to the competency measures of Process-Classifying

Table 40 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Classifying was 4.15 in favor of the first year pupils. The standard errors of the two means of 96.15 and 92.00 were 3.65 and 3.92, respectively, and the standard deviation 12.10 and 13.00. The standard error of the difference between means was 5.36 and

TABLE 40.--Significant differences on the competency measures (Process-Classifying) between thirty-nine second grade pupils

(Years of Exposure)

| Variables | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| One Year Exposure | 96.15 | 12.10 | 3.65 | | | |
| | | | | 6.31 | 5.33 | 1.19 |
| Two Years Exposure | 89.84 | 14.50 | 3.88 | | | |
| One Year Exposure | 96.15 | 12.10 | 3.65 | | | |
| | | | | 4.15 | 5.36 | .77 |
| Three Years Exposure | 92.00 | 13.00 | 3.92 | | | |
| Two Years Exposure | 89.84 | 14.50 | 3.88 | | | |
| | | | | 2.16 | 5.52 | .39 |
| Three Years Exposure | 92.00 | 13.00 | 3.92 | | | |

the "t" ratio, .77, with 22 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade pupils on the competency measures of the Process of Classifying was not significant.

### Comparison of performances of pupils with one year and two years exposure on the competency measures of Process-Classifying

Table 40 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Classifying was 6.31 in favor of the first year pupils. The standard errors of the two means of 96.15 and 89.84 were 3.65 and 3.88, respectively, and the standard deviation 12.10 and 14.50. The standard error of the difference between means was 5.33 and the "t" ratio, 1.19, with 25 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade pupils on the competency measures of the Process of Classifying was not significant. It was noted that the distribution was skewed in favor of accuracy in Classifying for this group.

### Comparison of performances of pupils with two years and three years exposure on the competency measures of Process-Classifying

Table 40 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Classifying was 2.16 in favor of the third year pupils. The standard errors of the two means of 89.84 and 92.00 were 3.88 and 3.92, respectively, and the standard deviation 14.50 and 13.00. The standard error of the difference between means was 5.52 and the "t" ratio, .39, with 25 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade pupils on the competency measures of the Process-Classifying was not significant.

## Performances on the competency measures for Process-Using Space/Time Relationships

The data obtained from the performance of the second grade pupils on the competency measures for the Process-Using Space/Time Relationships, based on years of exposure are presented in Tables 41 and 42 and the paragraphs which follow.

### One year exposure

The data on Process-Using Space/Time Relationships for the fifteen first year pupils ranged from a low of 17 to a high of 100, with a mean score of 78.50, a standard deviation of 24.50, and a standard error of the mean of 6.70. Eight or 53.33 per cent of the pupils scored above the mean, five or 33.33 per cent scored below the mean, and two or 13.33 per cent scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores were scattered along the continuum indicating a trend toward normality.

TABLE 41.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Using Space/Time Relationships) for thirty-six second grade pupils

(Years of Exposure)

| Percentage Scores | One Year Exposure | | Two Years Exposure | | Three Years Exposure | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 5 | 33.33 | 7 | 58.30 | 5 | 55.50 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | 3 | 20.00 | 1 | 8.35 | 2 | 2.22 |
| 70 - 79 | 2 | 13.33 | 2 | 16.65 | .. | .. |
| 60 - 69 | 2 | 13.33 | .. | .. | .. | .. |
| 50 - 59 | 2 | 13.33 | 1 | 8.35 | 2 | 22.20 |
| 40 - 49 | .. | .. | .. | .. | .. | .. |
| 30 - 39 | .. | .. | .. | .. | .. | .. |
| 20 - 29 | .. | .. | 1 | 8.35 | .. | .. |
| 10 - 19 | 1 | 6.67 | .. | .. | .. | .. |
| 0 - 9 | | | | | | |
| Totals | 15 | 99.99 | 12 | 100.00 | 9 | 99.90 |
| Mean | 78.50 | | 87.00 | | 88.94 | |
| Sigma | 24.70 | | 24.70 | | 20.10 | |
| $Se_m$ | | | | | | |

### Two years exposure

In Table 41 it may be noted that in Process-Using Space/Time Relationships, the twelve second year pupils ranged in scores from a low of 29 to a high of 100, with a mean score of 87.00, a standard deviation of 24.70, and a standard error of the mean of 7.50. Seven or 58.30 per cent of the pupils scored above the mean and four or 33.35 per cent scored below it. One or 8.35 per cent scored in the mean interval.

### Three years exposure

In Table 41 it may be noted that in Process-Using Space/Time Relationships the nine third year pupils ranged in scores from a low of 57 to a high of 100, with a mean score of 88.94, a standard deviation of 20.10, and a standard error of the mean of 7.10. Five or 55.50 per cent of the pupils scored above the mean and two or 22.22 per cent scored below it. Two or 22.22 per cent scored in the mean interval.

### Comparison of performances of pupils with one year and two years exposure on the competency measures of Process-Using Space/Time Relationships

Table 42 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Using Space/Time Relationships was 8.50 in favor of the second year pupils. The

TABLE 42.--Significant differences on the competency measures (Process-Using Space/Time Relationships) between thirty-six second grade pupils

(Years of Exposure)

| Variables | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| One Year Exposure | 78.50 | 24.70 | 6.70 | | | |
| | | | | 8.50 | 10.05 | .85 |
| Two Year Exposure | 87.00 | 24.70 | 7.50 | | | |
| One Year Exposure | 78.50 | 24.70 | 6.70 | | | |
| | | | | 10.44 | 9.76 | 1.07 |
| Three Years Exposure | 88.94 | 20.10 | 7.10 | | | |
| Two Years Exposure | 87.00 | 24.70 | 7.50 | | | |
| | | | | 1.94 | 10.34 | .19 |
| Three Years Exposure | 88.94 | 20.10 | 7.10 | | | |

standard errors of the two means of 78.50 and 87.00 were 24.70 and 24.70, respectively, and the standard deviation 6.70 and 7.50. The standard error of the difference between means was 10.05 and the "t" ratio, .85, with 25 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade pupils on the competency measures of the process of Using Space/Time Relationships was not significant.

Comparison of performances of pupils with one year and three years exposure on the competency measures of Process-Using Space/Time Relationships

Table 42 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Using Space/Time Relationships was 10.44 in favor of the third year pupils. The standard errors of the two means of 78.50 and 88.94 were 6.70 and 7.10, respectively, and the standard deviation 24.70 and 20.10. The standard error of the difference between means was 9.76 and the "t" ratio, 1.07, with 22 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade pupils on the competency measures of the Process of Using Space/Time Relationships was not significant.

Comparison of performances of pupils with two years and three years exposure on the competency measures of Process-Using Space/Time Relationships

Table 42 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Using Space/Time Relationships was 1.94 in favor of the third year pupils. The standard errors of the two means of 87.00 and 88.94 were 7.50 and 7.10, respectively, and the standard deviation 24.70 and 20.10. The standard error of the difference between means was 10.34 and the "t" ratio, .19, with 19 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of second grade pupils on the competency measures of the Process of Using Space/Time Relationships was not significant.

## Results of Performances of Third Grade Pupils Based on Years of Exposure

The results of the performances of the third grade pupils on the competency measures of *Science--A Process Approach* based on years of exposure are presented in Tables 43 through 46.

### Performances on the competency measures for Process-Predicting

The data obtained from the performance of the third grade pupils on the competency measures for the Process-Predicting based on years of exposure are presented in Tables 43 and 44 and the paragraphs which follow.

One year exposure

The data on Process-Predicting for the twelve first year pupils ranged from a low of 29 to a high of 100, with a mean score of 67.00, a standard deviation of 28.60, and a standard error of the mean of 8.62. Seven or 58.34 per cent of the pupils scored above the mean, four or 33.33 per cent scored below the mean, and one or 8.33 per cent scored

TABLE 43.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Predicting) for thirty third grade pupils

(Years of Exposure)

| Percentage Scores | One Year Exposure | | Two Years Exposure | | Three Years Exposure | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 2 | 16.67 | 5 | 55.60 | 8 | 88.90 |
| 90 - 99 | .. | .. | .. | .. | .. | .. |
| 80 - 89 | 3 | 25.00 | 1 | 11.10 | .. | .. |
| 70 - 79 | 2 | 16.67 | 2 | 22.70 | .. | .. |
| 60 - 69 | 1 | 8.33 | 1 | 11.10 | 1 | 11.10 |
| 50 - 59 | 1 | 8.33 | .. | .. | .. | .. |
| 40 - 49 | .. | .. | .. | .. | .. | .. |
| 30 - 39 | .. | .. | .. | .. | .. | .. |
| 20 - 29 | 3 | 25.00 | .. | .. | .. | .. |
| 10 - 19 | | | | | | |
| 0 - 9 | | | | | | |
| Totals | 12 | 100.00 | 9 | 100.00 | 9 | 100.00 |
| Mean | 67.00 | | 91.17 | | 100.00 | |
| Sigma | 28.60 | | 15.70 | | 12.60 | |
| $Se_m$ | 8.62 | | 5.50 | | 4.45 | |

within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores were scattered along the continuum indicating a trend toward normality.

Two years exposure

In Table 43 it may be noted that in Process-Predicting the nine second year pupils ranged in scores from a low of 63 to a high of 100, with a mean score of 91.17, a standard deviation of 15.70, and a standard error of the mean of 10.10. Five or 55.60 per cent of the pupils scored above the mean and four or 44.40 per cent scored below it. None scored in the mean interval.

Three years exposure

In Table 43 it may be noted that in Process-Predicting the nine third year pupils ranged in scores from a low of 63 to a high of 100, with a mean score of 100, a standard deviation of 12.60, and a standard error of the mean of 4.45. None of the pupils scored above the mean and one or 11.10 per cent scored below it. Eight or 88.90 per cent scored in the mean interval. Careful observation of these scores indicated them to be clustered toward the upper end of the distribution. It was noted that the distribution was skewed in favor of accuracy in Predicting.

Comparison of performances of pupils with one year and two years exposure on the competency measures of Process-Predicting

Table 44 presents the comparative measures for results described in the preceding sections. The difference

TABLE 44.--Significant differences on the competency measures (Process-Predicting) between thirty third grade pupils

(Years of Exposure)

| Variables | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| One Year Exposure | 67.00 | 28.60 | 8.62 | | | |
| | | | | 24.17 | 10.25 | 2.35 |
| Two Years Exposure | 91.17 | 15.70 | 5.55 | | | |
| One Year Exposure | 67.00 | 28.60 | 8.62 | | | |
| | | | | 33.00 | 9.70 | 3.41 |
| Three Years Exposure | 100.00 | 12.60 | 4.45 | | | |
| Two Years Exposure | 91.17 | 15.70 | 5.55 | | | |
| | | | | 8.83 | 7.11 | 1.24 |
| Three Years Exposure | 100.00 | 12.60 | 4.45 | | | |

between the mean performances in Predicting was 24.17 in favor of the second year pupils. The standard errors of the two means of 67.00 and 91.17 were 8.62 and 5.55, respectively, and the standard deviation 28.60 and 15.70. The standard error of the difference between means was 10.25 and the "t" ratio, 2.35, with 19 degrees of freedom. In that this value was greater than 1.96, it was concluded that at the .05 level of confidence the difference in performances of third grade pupils on the competency measures of the

Process of Predicting was significant.

### Comparison of performances of pupils with one year and three years exposure on the competency measures of Process-Predicting

Table 44 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Predicting was 33.00 in favor of the third year pupils. The standard errors of the two means of 67.00 and 100.00 were 8.62 and 4.45, respectively, and the standard deviation 28.60 and 12.60. In spite of the deviation from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be 9.70 and the "t" ratio, 3.41, with 19 degrees of freedom. In that this value was greater than 1.96, it was concluded that at the .05 level of confidence the difference in performances of third grade pupils on the competency measures of the Process of Predicting was significant.

### Comparison of performances of pupils with two years and three years exposure on the competency measures of Process-Predicting

Table 44 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Predicting was 8.83 in favor of the third year pupils. The standard errors of the two means of 91.17 and 100.00 were 5.55 and 4.45, respectively, and the standard deviation 15.70 and 12.60. In spite of the deviation from normality, the writer followed through on the planned procedures and found a standard error of the difference between means to be 7.11 and the "t" ratio, 1.24, with 16 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of these third grade pupils on the competency measures of the Process of Predicting was not significant.

### Performances on the competency measures for Process-Inferring

The data obtained from the performance of the third grade pupils on the competency measures for the Process-Inferring based on years of exposure are presented in Tables 45 and 46 and the paragraphs which follow.

#### One year exposure

The data on Process-Inferring for the eighteen first year pupils ranged from a low of 36 to a high of 100, with a mean score of 77.28, a standard deviation of 20.70, and a standard error of the mean of 5.03. Nine or 50.00 per cent of the pupils scored above the mean, seven or 38.89 per cent scored below the mean, and two or 11.11 per cent scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores were distributed along the continuum indicating a trend toward normality.

TABLE 45.--Frequency distribution of percentage scores and statistical measures of central tendency and variability on the competency measures (Process-Inferring) for forty-eight third grade pupils

(Years of Exposure)

| Percentage Scores | One Year Exposure | | Two Years Exposure | | Three Years Exposure | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 100 | 3 | 16.67 | 5 | 27.78 | 1 | 8.33 |
| 90 - 99 | 4 | 22.22 | 3 | 16.67 | 5 | 41.67 |
| 80 - 89 | 2 | 11.11 | 5 | 27.78 | 1 | 8.33 |
| 70 - 79 | 2 | 11.11 | 3 | 16.67 | 1 | 8.33 |
| 60 - 69 | 2 | 11.11 | 1 | 5.56 | 2 | 16.67 |
| 50 - 59 | 4 | 22.22 | 1 | 5.56 | 2 | 16.67 |
| 40 - 49 | .. | .. | .. | .. | .. | .. |
| 30 - 39 | 1 | 5.56 | .. | .. | .. | .. |
| 20 - 29 | | | | | | |
| 10 - 19 | | | | | | |
| 0 - 9 | | | | | | |
| Totals | 18 | 100.00 | 18 | 100.02 | 12 | 100.00 |
| Mean | 77.28 | | 87.78 | | 83.47 | |
| Sigma | 20.70 | | 14.50 | | 17.30 | |
| $Se_m$ | 5.03 | | 3.52 | | 5.22 | |

Two years exposure

In Table 45 it may be noted that in Process-Inferring the eighteen second year pupils ranged in scores from a low of 57 to a high of 100, with a mean score of 87.78, a standard deviation of 14.50, and a standard error of the mean of 3.52. Eight or 44.45 per cent of the pupils scored above the mean and five or 27.79 per cent scored below it. Five or 27.79 per cent scored in the mean interval. Careful observation of these scores indicated them to be normally distributed.

Three years exposure

The data on Process-Inferring for the twelve third year pupils ranges from a low of 57 to a high of 100, with a mean score of 83.47, a standard deviation of 17.30, and a standard error of the mean of 5.22. Six or 50.00 per cent of the pupils scored above the mean, five or 41.67 per cent scored below the mean, and one or 8.33 per cent scored within the mean interval. When these data were considered in terms of the representativeness of the sampling distribution, it was noted that the scores were normally distributed for this group.

Comparison of performances of pupils with one year and two years exposure on the competency measures of Process-Inferring

Table 46 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Inferring was 10.50 in favor of the second year pupils. The standard errors of the two means of 77.28 and 87.78 were 5.03 and 3.52, respectively,

TABLE 46.--Significant differences on the competency measures (Process-Inferring) between forty-eight third grade pupils

(Years of Exposure)

| Variables | Mean | Sigma | $SE_m$ | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
|---|---|---|---|---|---|---|
| One Year Exposure | 77.28 | 20.70 | 5.03 | | | |
| | | | | 10.50 | 6.14 | 1.71 |
| Two Years Exposure | 87.78 | 14.50 | 3.52 | | | |
| One Year Exposure | 77.28 | 20.70 | 5.03 | | | |
| | | | | 6.19 | 7.25 | .85 |
| Three Years Exposure | 83.47 | 17.30 | | | | |
| Two Years Exposure | 87.78 | 14.50 | 3.52 | | | |
| | | | | 4.31 | 6.29 | .69 |
| Three Years Exposure | 83.47 | 17.30 | 5.22 | | | |

and the standard deviation 20.70 and 14.50. The standard error of the difference between means was 6.14 and the "t" ratio, 1.71, with 34 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of third grade pupils on the competency measures of the Process of Inferring was not significant.

Comparison of performances of pupils with
one year and three years exposure on the
competency measures of Process-Inferring

Table 46 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Inferring was 6.19 in favor of the third year pupils. The standard erors of the two means of 77.28 and 83.47 were 5.03 and 5.22, respectively, and the standard deviation 20.70 and 17.30. The standard error of the difference between means was 7.25 and the "t" ratio, .85, with 28 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the differences in performances of third grade pupils on the competency measures of the Process of Inferring was not significant.

Comparison of performances of pupils with
two years and three years exposure on the
competency measures of Process-Inferring

Table 46 presents the comparative measures for results described in the preceding sections. The difference between the mean performances in Inferring was 4.31 in favor of the second year pupils. The standard errors of the two means of 87.78 and 83.47 were 3.52 and 5.22, respectively, and standard deviation 14.50 and 17.30. The standard error of the difference between means was 6.29 and the "t" ratio, .69, with 28 degrees of freedom. In that this value was less than 1.96, it was concluded that at the .05 level of confidence the difference in performances of third grade pupils on the competency measures of the Process of Inferring was not significant.

# CHAPTER IV

# SUMMARY AND CONCLUSIONS

## Review of Basic Elements of the Research

Science teaching in the elementary school today is in a state of genuine revolution. Both the conventional approaches to science teaching and the traditional subject-matter areas are being discarded. Of the many factors contributing to the revisions, probably the most important is the change in the philosophy of science education.

There has been a realization that the traditional approach to teaching science as a body of organized knowledge, learned by the acquisition of facts, is no longer a logical basis on which to organize a curriculum. The first task and central purpose of science education is to awaken in the child a sense of the joy, excitement, and intellectual power of science. Whether or not he will become a professional scientist, education in science will enlarge the child's appreciation of his world, and will lead him to a better understanding of the range and limits of man's control over nature.

The process approach to teaching science extends the notion of teaching generalizable ideas and skills. It adopts the idea that productive thinking can be encouraged in relation to each of the processes of science--observing, inferring, communicating, and so on. If transferable intellectual processes are to be developed in the child for application to continued learning, he must learn to carry out critical and disciplined thinking in connection with each of the processes of science. He must learn to be thoughtful and inventive in observing a variety of specific phenomena, in manipulating many different objects in space and time, in predicting a number of kind of events, as well as in producing hypotheses.

The desire to find a more effective way to provide meaningful learning experiences for disadvantaged children brought the establishment of various Education Improvement Projects. One of these projects is the Atlanta Education Improvement Project known as the Urban Laboratory. It brings into a cooperating unit the Atlanta Public Schools, Atlanta University, and Emory University. It was felt that cooperation between institutions of higher learning and public schools should be fostered in efforts to improve the education of inner-city children. One major emphasis of the project was a new elementary science curriculum, Science--A Process Approach.

The problem of this study was to compare and analyze the achievement of kindergarten and primary grade participants in Science--A Process Approach in relation to sex and years of exposure to the program.

The Descriptive-Survey Method of research, employing the technique of statistical analysis of test scores, was used to gather data required to fulfill the purposes of this study.

The sample of children used to obtain data for this study consisted of three children randomly selected from each class for each competency measure that was administered upon completion of an exercise by the classroom teacher. Competency measure data were available for eight kindergarten classes, eight first grades, eight second grade and eight third grade classes.

Some children in the sample had been exposed to the program during the 1965-66 school year. These were identified as third-year children. Other children were exposed for the first time in 1966-67. These were identified as second-year children. Those identified as first-year children were exposed to the program for the first time in 1967-68.

This study was conducted in the three schools in the Urban Laboratory in Atlanta, Georgia. Collecting, assembling, and treating data and writing of the research report were performed within the Urban Laboratory, Atlanta University, and the Public Library in Atlanta, Georgia.

The instrument used in this study for assessing the outcomes of instruction was the "competency measure," that was developed for the immediate assessment of what a child is able to do upon completion of an exercise in Science--A Process Approach. The competency measure consists of tasks intended to assess the achievement of the objectives for each exercise.

The major purpose of this study was to assess the performances of kindergarten, first, second, and third grade pupils in Science--A Process Approach.

Statistically, the purpose of this research was to test the following hypotheses, based on the significance of the "t" ratios. In Science--A Process Approach

1. Kindergarten boys will not perform at a higher level than kindergarten girls.

2. Children in grade one with previous exposure will not perform at a higher level than children in the program for the first time.

3. Children in grade two with three years of previous exposure will not perform at a higher level than children with one year of previous exposure or children in the program for the first time.

4. There is no advantage for children in the third grade with the longer experience.

5. For the total groups assessed, boys will not perform at a higher level than girls.

The limitations of this research were that all data were derived from competency measures that are a part of the built-in evaluation in Science--A Process Approach; no consideration was given to the teachers' competence in instructional procedures or in administering the evaluation instruments; and the writer had no control of incidental learning outside of the classroom.

The procedural steps taken in carrying out this study were:

1. The related literature was surveyed, summarized, and incorporated in the finished thesis copy.

2. Competency measure data for kindergarten and grades one through three were collected, organized, and assembled in appropriate tables as indicated by the purposes of the study.

3. The data were statistically treated with reference to the mean, standard deviation, standard error of the mean, standard error of difference between means, and "t" ratios.

4. The null hypotheses were rejected at the .05 level of significance.

5. Conclusions, implications and recommendations based upon the findings were incorporated in the finished thesis.

## Summary of Related Literature

The literature pertinent to this study may be found in the epitomized statements below:

1. Experimentation and innovation have been at the heart of the major curriculum developments for elementary and secondary education during the past decade.

2. New approaches to the teaching of science require the construction of behavioral objectives that are clearly and specifically defined in terms of pupil behavior, and the performance expected of a student if the objective has been achieved.

3. Behavioral objectives will enable the teacher to discover and teach fundamental processes that underlie the fields of science and scientific behavior.

4. School systems should provide and require supplementary work in the methodology and content of

the new science programs for teachers before they attempt to teach the new courses. Also, colleges should prepare graduates with a good background in both subject matter and methodology for the new science courses.

5. Long-range evaluation programs should be established to determine the effectiveness of the new approaches in meeting the objectives of the science program.

6. Science education in the elementary school should provide children a practical understanding of the processes of science that will enable them to apply a scientific mode of thought to a wide range of problems in life.

## Findings of the Study

In accordance with the purposes of this study, the findings are summarized in Tables 47-48 and under the appropriate data-captions below:

### Performances of kindergarten boys and girls

1. The means for the Process-Observing were 95.97 and 90.30 boys and girls, respectively. The distribution of scores indicated high accuracy in the Process of Observing for both boys and girls. The "t" ratio was 1.15 which was not significant.

2. The means for the Process-Using Space/Time Relationships were 100 and 95.97 for boys and girls, respectively. The distribution of scores indicated high accuracy in the Process of Using Space/Time Relationships for both boys and girls. The "t" ratio was 1.43 which was not significant.

3. The means for the Process-Classifying were 88.50 and 100 for boys and girls, respectively. The score received by the girls indicated accuracy in the Process of Classifying was mastered by all. The "t" ratio was 1.53 which was not significant.

SUMMARY TABLE 47

SUMMARY OF DISTRIBUTIONS AND "t" RATIOS FOR DATA OBTAINED ON THE COMPETENCY MEASURES FOR SCIENCE--A PROCESS APPROACH (BOYS AND GIRLS)

| Grade and Process | Boys | | | Girls | | | Difference Data | | Index |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Sigma | SE | Mean | Sigma | SE | $M_1 - M_2$ | $SE_{m_1-m_2}$ | "t" |
| Kindergarten | | | | | | | | | |
| Observing | 95.97 | 23.20 | 4.04 | 90.30 | 22.20 | 2.84 | 5.67 | 4.94 | 1.15 |
| Using Space/Time Relationships | 100.00 | 6.42 | 1.44 | 95.97 | 12.40 | 2.43 | 4.03 | 2.82 | 1.43 |
| Classifying | 88.50 | 15.00 | 7.50 | 100.00 | .00 | .00 | 11.50 | 7.50 | 1.53 |
| First Grade | | | | | | | | | |
| Observing | 92.00 | 17.60 | 3.67 | 90.26 | 17.20 | 3.04 | 1.74 | 4.76 | .37 |
| Using Space/Time Relationships | 91.75 | 13.90 | 2.63 | 87.74 | 16.90 | 2.95 | 4.01 | 3.95 | 1.01 |
| Measuring | 88.94 | 19.20 | 4.67 | 88.39 | 17.70 | 4.30 | .55 | 6.36 | .09 |
| Using Numbers | 100.00 | 2.80 | .81 | 99.50 | 12.00 | 3.33 | .50 | 3.42 | .15 |
| Second Grade | | | | | | | | | |
| Using Numbers | 74.50 | 12.50 | 4.05 | 72.50 | 14.70 | 4.90 | 2.00 | 6.36 | .31 |
| Classifying | 93.33 | 12.30 | 3.07 | 91.78 | 14.50 | 3.17 | 1.55 | 4.42 | .35 |
| Using Space/Time Relationships | 90.06 | 24.60 | 5.97 | 88.94 | 26.10 | 6.34 | 1.12 | 8.71 | .13 |
| Communicating | 85.61 | 20.50 | 7.27 | 89.50 | 15.00 | 4.52 | 3.89 | 8.56 | .45 |
| Third Grade | | | | | | | | | |
| Inferring | 83.10 | 18.10 | 3.70 | 80.15 | 18.10 | 3.86 | 3.55 | 5.35 | .66 |
| Predicting | 82.13 | 26.20 | 6.55 | 86.81 | 23.60 | 6.48 | 4.68 | 9.21 | .51 |

SUMMARY TABLE 48

SUMMARY OF DISTRIBUTIONS AND "t" RATIOS FOR DATA OBTAINED ON THE COMPETENCY MEASURES FOR SCIENCE--A PROCESS APPROACH (YEARS OF EXPOSURE)

| Grade and Process | One Year Exposure | | | Two Years Exposure | | | Three Years Exposure | | | Difference Data | | Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Sigma | $SE_m$ | Mean | Sigma | $SE_m$ | Mean | Sigma | $SE_m$ | $M_1-M_2$ | $SE_{m_1-m_2}$ | "t" |
| First Grade | | | | | | | | | | | | |
| Observing | 82.12 | 18.70 | 4.19 | 96.44 | 14.30 | 2.41 | | | | 14.32 | 4.84 | 3.96 |
| Using Space/Time Relationships | 85.61 | 15.70 | 3.08 | 94.75 | 13.20 | 2.23 | | | | 9.14 | 3.80 | 2.41 |
| Using Numbers | 93.39 | 13.70 | 4.84 | 100.00 | .00 | .00 | | | | 6.61 | 4.84 | 1.37 |
| Measuring | 91.17 | 13.20 | 3.98 | 98.25 | 11.80 | 2.46 | | | | 27.08 | 4.68 | 5.79 |
| Second Grade | | | | | | | | | | | | |
| Communicating | 84.50 | 14.10 | 4.98 | 72.83 | 16.70 | 7.45 | .. | .. | .. | 11.67 | 8.96 | 1.38 |
| Communicating | 84.50 | 14.10 | 4.98 | .. | .. | .. | 100.00 | .00 | .00 | 15.50 | 4.98 | 3.11 |
| Communicating | .. | .. | .. | 72.83 | 16.70 | 7.45 | 100.00 | .00 | .00 | 27.17 | 7.45 | 3.65 |
| Using Numbers | 64.61 | 9.90 | 3.50 | 76.17 | 11.80 | 5.28 | .. | .. | .. | 11.56 | 6.33 | 1.83 |
| Using Numbers | 64.61 | 9.90 | 3.50 | .. | .. | .. | 86.17 | 14.60 | 6.52 | 19.56 | 7.40 | 2.64 |
| Using Numbers | .. | .. | .. | 76.17 | 11.80 | 5.28 | 86.17 | 14.60 | 6.52 | 10.00 | 8.39 | 1.19 |
| Classifying | 96.15 | 12.10 | 3.65 | 89.84 | 14.50 | 3.88 | .. | .. | .. | 6.31 | 5.33 | 1.19 |
| Classifying | 96.15 | 12.10 | 3.65 | .. | .. | .. | 92.00 | 13.00 | 3.92 | 4.15 | 5.36 | .77 |
| Classifying | .. | .. | .. | 89.84 | 14.50 | 3.88 | 92.00 | 13.00 | 3.92 | 2.16 | 5.52 | .39 |
| Using Space/Time Relationships | 78.50 | 24.70 | 6.70 | 87.00 | 24.70 | 7.50 | .. | .. | .. | 8.50 | 10.05 | .85 |
| Using Space/Time Relationships | 78.50 | 24.70 | 6.70 | .. | .. | .. | 88.94 | 20.10 | 7.10 | 10.44 | 9.76 | 1.07 |
| Using Space/Time Relationships | .. | .. | .. | 87.00 | 24.70 | 7.50 | 88.94 | 20.10 | 7.10 | 1.94 | 10.34 | .19 |
| Third Grade | | | | | | | | | | | | |
| Inferring | 77.28 | 20.70 | 5.03 | 87.78 | 14.50 | 3.52 | .. | .. | .. | 10.50 | 6.14 | 1.71 |
| Inferring | 78.28 | 20.70 | 5.03 | .. | .. | .. | 83.47 | 17.30 | 5.22 | 6.19 | 7.25 | .85 |
| Inferring | .. | .. | .. | 87.78 | 14.50 | 3.52 | 83.47 | 17.30 | 5.22 | 4.31 | 6.29 | .69 |
| Predicting | 67.00 | 28.60 | 8.62 | 91.17 | 15.70 | 10.10 | .. | .. | .. | 24.17 | 13.27 | 1.82 |
| Predicting | 67.00 | 28.60 | 8.62 | .. | .. | .. | 100.00 | 12.60 | 4.45 | 33.00 | 9.70 | 3.41 |
| Predicting | .. | .. | .. | 91.17 | 15.70 | 10.10 | 100.00 | 12.60 | 4.45 | 8.83 | 11.05 | .80 |

Performances of first grade boys and girls

1. The means for the Process-Observing were 92.00 and 90.26 for boys and girls, respectively. The distribution of scores indicated accuracy in the Process of Observing for both boys and girls. The "t" ratio was .37 which was not significant.

2. The means for the Process-Measuring were 88.94 and 88.39 for boys and girls, respectively. The distribution of scores indicated accuracy in the Process of Measuring for both boys and girls. The "t" ratio was .09 which was not significant.

3. The means for the Process-Using Numbers were 100 and 99.50 for boys and girls, respectively. The distribution of scores indicated accuracy in the Process of Using Numbers for both boys and girls. The "t" ratio was .15 which was not significant.

Performances of second grade boys and girls

1. The means for the Process-Using Numbers were 74.50 and 72.50 for boys and girls, respectively. The distribution of scores reflected low accuracy in the Process of Using Numbers for this group. The "t" ratio was .31 which was not significant.

2. The means for Process-Classifying were 93.33 and 91.78 for boys and girls, respectively. The distribution of scores indicated accuracy in the Process of Classifying for this group. The "t" ratio was .35 which was not significant.

3. The means for the Process-Using Space/Time Relationships were 90.06 and 88.94 for boys and girls, respectively. The distribution of scores along the continuum indicated low accuracy in the Process of Classifying for the girls. The "t" ratio was .13 which was not significant.

4. The means for the Process-Communicating were 85.61 and 89.50 for boys and girls, respectively. The "t" ratio was .45 which was not significant.

Performances of third grade boys and girls

1. The means for the Process-Predicting were 82.13 and 86.81 for boys and girls, respectively. The

scores were slightly clustered at the upper end of the distribution for the boys. The "t" ratio was .51 which was not significant.

2. The means for the Process-Inferring were 83.70 and 80.15 for boys and girls, respectively. The distribution of scores indicated a normal distribution for the group. The "t" ratio was .66 which was not significant.

Performances of first grade pupils

1. The means for the Process-Observing were 82.12 and 96.44 for first year and second year pupils, respectively. Scores were normally distributed for first year pupils. The distribution of scores indicated accuracy in the Process of Observing for second year pupils. The "t" ratio was 3.96 which was very significant.

2. The means for the Process-Using Space/Time Relationships were 85.61 and 94.75 for first year and second year pupils, respectively. The distribution of scores indicated accuracy in the Process of Using Space/Time Relationships for the second year group. The "t" ratio was 2.41 which was significant.

3. The means for the Process-Using Numbers were 93.39 and 100 for first year and second year pupils, respectively. It was noted that all second year pupils had perfect scores of 100 indicating high accuracy in the Process of Using Numbers. The "t" ratio was 1.37 which was not significant.

4. The means for the Process-Measuring were 91.17 and 98.25 for first year and second year pupils, respectively. The distribution of scores toward the lower end of the distribution indicated a lack of accuracy in Measuring for the first year group. The distribution of scores indicated accuracy in the Process of Measuring for the second year pupils. The "t" ratio was 5.79 which was very significant.

Performances of second grade pupils

1. The means for the Process-Communicating were 84.50 and 72.83 for first year and second year

pupils, respectively. The "t" ratio was 1.38 which was not significant.

2. The means for the Process-Communicating were 84.50 and 100 for first year and third year pupils, respectively. The distribution of scores indicated high accuracy in the Process of Communicating for third year pupils. The "t" ratio was 3.11 which was significant.

3. The means for the Process-Communicating were 72.83 and 100 for second year and third year pupils, respectively. The "t" ratio was 3.65 which was significant.

4. The means for the Process-Using Numbers were 64.61 and 76.17 for first year and second year pupils, respectively. The "t" ratio was 1.83 which was not significant.

5. The means for the Process-Using Numbers were 64.61 and 86.17 for first year and third year pupils, respectively. The "t" ratio was 2.64 which was significant.

6. The means for the Process-Using Numbers were 76.17 and 86.17 for second year and third year pupils, respectively. The "t" ratio was 1.19 which was not significant.

7. The means for the Process-Classifying were 96.15 and 89.84 for first year and second year pupils, respectively. The distribution of scores indicated accuracy in the Process of Observing for this group. The "t" ratio was 1.19 which was not significant.

8. The means for the Process-Classifying were 96.15 and 92.00 for first year and third year pupils, respectively. The "t" ratio was .77 which was not significant.

9. The means for the Process-Classifying were 89.84 and 92.00 for second year and third year pupils, respectively. The "t" ratio was .39 which was not significant.

10. The means for the Process-Using Space/Time Relationships were 78.50 and 87.00 for first year and second year pupils, respectively. Scores for the first year pupils were scattered along the

continuum indicating a normality in distribution. The "t" ratio was .85 which was not significant.

11. The means for the Process-Using Space/Time Relationships were 78.50 and 88.94 for first year and third year pupils, respectively. The "t" ratio was 1.07 which was not significant.

12. The means for the Process-Using Space/Time Relationships were 87.00 and 88.94 for second year and third year pupils, respectively. The "t" ratio was .19 which was not significant.

<u>Performances of third grade pupils</u>

1. The means for the Process-Predicting were 67.00 and 91.17 for first year and second year pupils, respectively. The scattering of scores along the continuum indicated normal distribution for the first year pupils. The "t" ratio was 2.35 which was significant.

2. The means for the Process-Predicting were 67.00 and 100 for first year and third year pupils, respectively. The distribution of scores indicated high accuracy in the Process of Predicting for third year pupils. The "t" ratio was 3.41 which was significant.

3. The means for the Process-Predicting were 91.17 and 100 for second year and third year pupils, respectively. The "t" ratio was 1.24 which was not significant.

4. The means for the Process-Inferring were 77.28 and 87.78 for first year and second year pupils, respectively. The distribution of scores along the continuum indicated normal distribution for this group. The "t" ratio was 1.71 which was not significant.

5. The means for the Process-Inferring were 77.28 and 83.47 for first year and third year pupils, respectively. The distribution of scores along the continuum indicated normal distribution for this group. The "t" ratio was .85 which was not significant.

6. The means for the Process-Inferring were 87.78 and 83.47 for second year and third year pupils, respectively. There was a normal distribution of scores for this group. The "t" ratio was .69 which was not significant.

## Conclusions

From the findings of this study, the following conclusions were drawn:

1. There were no statistically significant differences between boys and girls on any of the competency measures, therefore it seemed logical to conclude that the sex of children in grades kindergarten through three did not affect performance level in _Science--A Process Approach_. Thus, the null hypotheses for performances between sex were validated.

2. There were significant findings on all Processes for first grade pupils with two years exposure to _Science--A Process Approach_. Therefore, it seemed logical to conclude that previous exposure did affect significantly the performance level in _Science--A Process Approach_. The null hypothesis was rejected.

3. There were no statistically significant differences in the level of performance for second and third graders who had three years of exposure to _Science--A Process Approach_ and second and third graders who had from one to two years of exposure to _Science--A Process Approach_. The null hypotheses were validated.

## Implications

The findings and conclusions of this study warrant the following statements of implications:

1. It would appear that the sex of children is not a factor to be considered in organizing for the teaching of _Science--A Process Approach_.

2. It would appear that exposure to _Science--A Process Approach_ in kindergarten has a tremendous

impact on achievement in science in the first grade.

3. Generally, one might imply that beyond the first grade the lack of previous exposure to Science--A Process Approach does not seriously impair the level of performance of pupils. However, the more verbal the Process, the more apparent the affect.

## Recommendations

From the findings and conclusions of this research report, the following recommendations were drawn:

1. An evaluation program should be a part of all experimental programs to measure both the qualitative and quantitative effectiveness of the programs.

2. It is recommended that Science--A Process Approach be extended to all grades in the elementary schools.

3. It is recommended that the Atlanta Public School System adopt Science--A Process Approach as a system wide science curriculum in the elementary schools.

4. It is further recommended that the college and university level methods courses be so geared as to prepare pre-service and in-service teachers to teach Science--A Process Approach.

5. It is recommended that further study be done in this area on larger and more varied groups of pupils to reject or confirm the conclusions and implications found in this study.

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